BROOKHAVEN NATIONAL LABORATORY

Site Environmental Report 2014

VOLUME 1

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SITE ENVIRONMENTAL REPORT

BROOKHAVEN NATIONAL LABORATORY

Volume I

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A Note from the Editor

Throughout the Site Environmental Report, there are many references to Brookhaven National Laboratory (BNL), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA). These acronyms, and others that are explained in each chapter, are used interchangeably with their spelled-out forms as an aid to readers. The most up-to-date, accurate version of this report is online at <http://www.bnl.gov/ewms/ser/>.

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Executive Summary

Brookhaven National Laboratory (BNL) is operated and managed for the U.S. Department of Energy's (DOE's) Office of Science by Brookhaven Science Associates (BSA), a partnership formed by Stony Brook University and Battelle Memorial Institute. For more than 60 years, the Laboratory has played a lead role in the DOE Science and Technology mission and continues to contribute to the DOE missions in energy resources, environmental quality, and national security. BNL manages its world-class scientific research with particular sensitivity to environmental issues and community concerns. The Laboratory's Environmental, Safety, Security and Health Policy reflects the commitment of BNL's management to fully integrate environmental stewardship into all facets of its mission and operations.

BNL prepares an annual Site Environmental Report (SER) in accordance with DOE Order 231.1B, Environment, Safety and Health Reporting. The report is written to inform the public, regulators, employees, and other stakeholders of the Laboratory's environmental performance during the calendar year in review. Volume I of the SER summarizes environmental data; environmental management performance; compliance with applicable DOE, federal, state, and local regulations; and performance in restoration and surveillance monitoring programs. BNL has prepared annual SERs since 1971 and has documented nearly all of its environmental history since the Laboratory's inception in 1947.

Volume II of the SER, the Groundwater Status Report, also is prepared annually to report on the status of groundwater protection and restoration efforts. Volume II includes detailed technical summaries of groundwater data and treatment system operations, and is intended for regulators and other technically oriented stakeholders. A brief summary of the information contained in Volume II is included in Chapter 7, Groundwater Protection, of this volume.

Both reports are available in print and as downloadable files on the BNL web page at <http://www.bnl.gov/esh/ser/>. An electronic version on compact disc is distributed with each printed report. In addition, a summary of Volume I is prepared each year to provide a general overview of the report, and is distributed with a compact disc containing the full report.

ENVIRONMENTAL MANAGEMENT SYSTEM

The Laboratory's Integrated Safety Management System (ISMS) incorporates management of environment (i.e., environmental protection and pollution prevention), safety, and health issues into all work planning. BNL's ISMS ensures that the Laboratory integrates DOE's

five Core Functions and seven Guiding Principles into all work processes. These processes contributed to BNL's achievement of registration under both the International Organization for Standardization (ISO) 14001 Standard (for the Laboratory's Environmental Management System [EMS]) and the Occupational Safety

and Health Assessment Series (OHSAS) 18001 Standard (for the Laboratory's Safety and Health Program). Both standards require an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take correction actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

An EMS was fully established at BNL in 2001 to ensure that environmental issues are systematically identified, controlled, and monitored. The EMS also provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual environmental improvement. The cornerstone of the Laboratory's EMS is BNL's Environment, Safety, Security, and Health (ESSH) Policy. This policy makes clear the Laboratory's commitments to environmental stewardship, the safety and health of employees, and the security of the site. Specific environmental commitments in the policy include compliance, pollution prevention, conservation, community outreach, and continual improvement. The policy is posted throughout the Laboratory and on the BNL website. It also is included in all training programs for new employees, guests, and contractors.

The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized ISO 14001 Environmental Management Standard. BNL was the first laboratory under the DOE Office of Science to become officially registered to this standard. BNL was also the first DOE Office of Science Laboratory to achieve registration under the OHSAS 18001 (Occupational Health & Safety) Standard. Each certification requires the Laboratory to undergo annual audits by an accredited registrar to assure that the systems are maintained and to identify evidence of continual improvement. In 2014, an EMS and OHSAS surveillance audit determined that BNL remains in conformance with both standards. In recommended continued EMS certification, auditors from NSF-International Strategic Registrations, Ltd., found one minor nonconformance in BNL's Natural Resource program involving the tagging of artifacts that are part of the Historical Resource Identification Tag Program.

Executive Order 13514, signed in 2009, sets sustainability goals for federal agencies and focuses on making improvements in environmental, energy, and economic performance. It requires federal agencies to set a greenhouse gas emissions reduction target, increase energy efficiency, reduce fleet petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies. The Laboratory's EMS objectives and targets have been established to mirror these requirements.

The Laboratory's Pollution Prevention (P2) Program is an essential element for the successful implementation of BNL's EMS. The P2 Program reflects the national and DOE pollution prevention goals and policies, and represents an ongoing effort to make pollution prevention and waste minimization an integral part of the Laboratory's operating philosophy. Pollution prevention and waste reduction goals have been incorporated as performance measures into the DOE contract with Brookhaven Science Associates and into BNL's ESSH Policy. The overall goal of the P2 Program is to create a systems approach that integrates pollution prevention and waste minimization, resource conservation, recycling, and affirmative procurement into all planning and decision making.

Two new P2 proposals were funded in 2014, for a combined investment of approximately \$9,000. The anticipated annual savings from these projects is estimated at \$10,000, for an average payback period of approximately one year. Initiatives to reduce, recycle, and reuse approximately 35.5 million pounds of industrial, sanitary, hazardous, and radiological waste through the P2 program resulted in more than \$4 million in cost avoidance or savings in 2014.

Chapter 2 of this report describes the elements and implementation of BNL's EMS in further detail.

BNL'S ENVIRONMENTAL MANAGEMENT PROGRAM

BNL's Environmental Management Program consists of several Laboratory-wide and facility-specific environmental monitoring and

surveillance programs. These programs identify potential pathways of public and environmental exposure and evaluate the impacts BNL activities may have on the environment. An overview of the Laboratory's environmental programs and a summary of performance for 2014 follow.

Compliance Monitoring Program

BNL has an extensive program in place to ensure compliance with all applicable environmental regulatory and permit requirements. The Laboratory must comply with more than 100 sets of federal, state, and local environmental regulations, numerous site-specific permits, 12 equivalency permits for the operation of groundwater remediation systems, and several other binding agreements. In 2014, the Laboratory operated in compliance with most of the requirements, and any instance of noncompliance was reported to regulatory agencies and corrected expeditiously. Routine inspections conducted during the year found no significant instances of non-compliance. Emissions of carbon monoxide and sulfur dioxide from BNL's Central Steam Facility (CSF) are discussed in Air Monitoring Program on the following page. Halon portable fire extinguishers continue to be removed and replaced by dry-chemical or clean agent units.

Monitoring of BNL's potable water system indicated that all drinking water requirements were met during 2014. Most of the liquid effluents discharged to surface water and groundwater met applicable New York State Pollutant Discharge Elimination (SPDES) permit requirements. Eight excursions above permit limits were reported for the year; four occurred at the Sewage Treatment Plant (two total nitrogen, and two mercury), two at recharge basin 002 (oil and grease and HEDP), one at recharge basin 010 (pH), and one at recharge basin 006B (oil and grease). The permit excursions were reported to the New York State Department of Environmental Conservation (NYSDEC) and the Suffolk County Department of Health Services (SCDHS) and corrective actions were taken. Groundwater monitoring at the Laboratory's Major Petroleum Facility (MPF) and Waste Management Facility (WMF) continued to demonstrate that current oil storage and

transfer operations are not affecting groundwater quality.

Efforts to minimize impacts of spills of materials continued in 2014. There were 28 spills in 2014, a 34 percent reduction compared to 2013. Eleven of the 28 spills met regulatory agency reporting criteria. The severity of releases were minor, and all releases were cleaned up to the satisfaction of NYSDEC.

External environmental inspections or reviews conducted in 2014 by federal, state, and local agencies that oversee BNL activities included:

- *Air Compliance.* In December, BNL representatives accompanied NYSDEC on a site tour of Title V permitted facilities; there were no issues identified.
- *Potable Water.* In October, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. Corrective actions for all deficiencies identified during the inspections were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.
- *Sewage Treatment Plant (STP).* SCDHS conducted quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent; no performance or operational issues were identified. NYSDEC performed an annual surveillance inspection in February; there were no issues identified.
- *Recharge Basins.* In December, SCDHS inspected several on-site SPDES-regulated outfalls and collected samples; there were no issues identified.
- *Major Petroleum Facility.* In April, the annual NYSDEC inspection of the MPF was performed. Seven findings that required corrective action were identified: evaluation/repairs of the cathodic protection system for Tanks 9 and 10; need for repairs of the secondary containment for Tank 3 to satisfy permeability requirements for stored product; shear valve for mid-grade dispenser not installed correctly; additional cleanup required from a previously reported spill of motor oil from failed piping on Tank 423-17; completion of ten-year Out-of-Service inspections/reporting for Tanks 3 and 6;

minor paint failure on the shell plate of Tank 5; and the need to update BNL's State Pollution Discharge Elimination System Best Management Practices Plan. Five of the seven findings were corrected in 2014 in accordance with NYSDEC directives. The remaining two findings continue to be evaluated and addressed, with progress being reported to NYSDEC on a regular basis.

- *Chemical Bulk Storage (CBS) Facilities.* In April, an inspection by NYSDEC of the CBS facilities found one finding related to the integrity of the containment systems for truck transfer areas for Tanks 634-02 and 635-04. Repairs were made to stress cracks in accordance with NYSDEC directives.
- *Resource Conservation and Recovery Act Inspections(RCRA).* In September, EPA performed a RCRA inspection; there were no issues identified.

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs during 2014 and observed a programmatic self-assessment of BNL's waste management programs. Specific elements of the self-assessment included compliance and conformance with hazardous, industrial, PCB, and regulated medical, mixed, and radioactive waste management. A casual analysis was performed and a corrective action plan was prepared for identified nonconformances, and progress on the corrective actions was tracked to closure.

Chapter 3 of this report describes BNL's Compliance Program and status in further detail.

Air Quality Program

BNL monitors radioactive emissions at three facilities on site to ensure compliance with the requirements of the Clean Air Act. EPA regulations require continuous monitoring of all sources that have the potential to deliver an annual radiation dose greater than 0.1 mrem to a member of the public; all other facilities capable of delivering any radiation dose require periodic confirmatory sampling.

During 2014, Laboratory facilities released a total of 7,535 curies of short-lived radioactive gases. BNL's Brookhaven Linac Isotope

Producer (BLIP) is the only facility subject to EPA's continuous monitoring requirements. Oxygen-15 (half-life: 122 seconds) and carbon-11 (half-life: 20.4 minutes) emitted from the BLIP constituted more than 99.99 percent of radiological air emissions on site in 2014.

The Laboratory conducts ambient radiological air monitoring to verify local air quality and to assess possible environmental and health impacts from BNL operations. Samples collected from air monitoring stations around the perimeter of the site were analyzed for tritium and gross alpha and beta airborne activity. Results for 2014 continued to demonstrate that on-site radiological air quality was consistent with air quality measured at locations in New York State that are not located near radiological facilities.

Various state and federal regulations governing nonradiological releases require facilities to conduct periodic or continuous emissions monitoring to demonstrate compliance with emission limits. The CSF is the only BNL facility that requires monitoring. In 2014, there was one excess opacity measurement recorded by CSF Boiler 6 during scheduled service work on the continuous opacity system, and five excess opacity measurements recorded by CSF Boiler 7. Two of the Boiler 7 excess opacity readings occurred during boiler startup and were due to unknown causes; two excess readings were the result of a blower motor failure; and one excess opacity reading occurred during startup after the blower motor was replaced. During quarterly quality assurance tests of the opacity monitors for Boilers 6 and 7, multiple 6-minute periods greater than 20 percent opacity were also recorded. All of the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to NYSDEC.

Because natural gas prices were lower than residual fuel oil prices throughout 2014, BNL's CSF used natural gas to supply more than 99.3 percent of the heating and cooling needs of the Laboratory's major facilities. As a result, emissions of particulates, oxides of nitrogen, sulfur dioxide, and volatile organic compounds (VOCs) were well below the respective regulatory permit criteria pollutant limits.

Chapter 4 of this report describes BNL's Air Quality Program and monitoring data in further detail.

Water Quality Surveillance Program

The Laboratory discharges treated wastewater into the headwaters of the Peconic River via BNL's STP, and non-contact cooling water and stormwater runoff to groundwater via recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and careful operation of treatment facilities ensure that these discharges comply with all applicable requirements and that the public, employees, and the environment are protected.

In 2014, the average gross alpha and beta activity levels in the STP discharge were within the typical range of historical levels and well below New York State Drinking Water Standards (NYS DWS). Tritium was not detected above method detection limits throughout the year. There was also no detection of cesium-137 (Cs-137), strontium-90 (Sr-90), or other gamma-emitting nuclides attributable to BNL operations. The STP is also monitored for non-radiological contaminants. In 2014, monitoring of the STP effluent showed that organic and inorganic parameters were within SPDES effluent limitations or other applicable standards.

Discharges to recharge basins are sampled throughout the year and analyzed for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. Each recharge basin is a permitted point-source discharge under the Laboratory's SPDES permit. In 2014, there were no reported gamma-emitting nuclides attributable to BNL operations in any discharges to recharge basins. Disinfection byproducts continue to be detected in discharges to recharge basins just above the method detection limit due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics (i.e., metals) were detected; however, their presence is due primarily to sediment run-off in stormwater discharges.

To assess the potential impact of discharges on the water quality of the Peconic River, surface water monitoring is conducted at several

locations upstream and downstream of the STP discharge. The Carmans River, located west of BNL, is monitored as a geographical control location for comparative purposes, as it is not affected by Laboratory operations. Radiological data from Peconic River surface water sampling in 2014 show that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from off-site and control locations. In addition, all detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the STP, and tritium was not detected above method detection limits in any surface water samples. Inorganic data from Peconic River samples collected upstream, downstream, and at control locations demonstrated that elevated amounts of aluminum and iron detected in the river are associated with natural sources. Concentrations of silver, copper, lead, and zinc detected were consistent with concentrations found in the STP discharge, and were within BNL SPDES permit limits.

Chapter 5 of this report describes BNL's Water Quality Surveillance Program and monitoring data in further detail.

Natural and Cultural Resource Management Program

The BNL Natural Resource Management Program was designed to promote stewardship of the natural resources found on site and to integrate natural resource management and protection with the Laboratory's scientific mission. The goals of the program include protecting and monitoring the ecosystem on site, conducting research, and communicating with the public, stakeholders, and staff members regarding environmental issues.

BNL conducts routine monitoring of flora and fauna to assess the impact, if any, of past and present activities on the Laboratory's natural resources. Generally, deer sampled on site or within 1 mile of the Laboratory contain higher concentrations of Cs-137 than deer sampled from more than 1 mile off site. This is most likely because on-site deer consume small amounts of contaminated soil and graze on

vegetation growing in soil where elevated Cs-137 levels are known to exist. The average on-site concentration in 2014 in deer meat was 0.60 pCi/g, wet weight (wet weight is before a sample is dried for analysis and the form most likely to be consumed). The average concentration of Cs-137 in deer meat taken from off site was 0.56 pCi/g, wet weight. The New York State Department of Health (NYSDOH) has formally reviewed the potential public health risk associated with elevated levels of Cs-137 in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted.

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Sampling is now alternated each year either as part of BNL's routine surveillance monitoring program or sampling is performed as part of the post-cleanup monitoring for the Peconic River remediation project. In 2014, results from surveillance monitoring of fish from the Peconic River showed low levels of Cs-137, whereas Cs-137 was not detected in all samples from the Carmans River. Levels of Cs-137 in all fish species are within the range of results historically seen from the Peconic River.

Metals analysis of fish in 2014 focused on mercury due to its known health risk. In general, there is a trend of decreasing mercury levels in fish downstream from BNL's STP, with the highest concentration of 0.73 mg/kg measured in a composite of brown bullhead on site. Polychlorinated biphenyl (PCB) analysis in fish was discontinued off site, but continued to be performed for fish on site. Very low levels of Aroclor 1254 and 1260 were detected in several samples.

Radiological analysis of sediments from three Peconic River locations showed low levels of Cs-137, ranging from 0.32 pCi/g to 5.49 pCi/g, which are consistent with previous analyses of the river sediments. Analysis of sediment for mercury identified values ranging from 0.33 mg/kg to 7.40 mg/kg. The 7.40 mg/kg value was from a sample taken at the on-site PR-WC-06 area, and was above the 2.0 mg/kg clean-up goal. This result, along with the fact that concentrations above 2.0 mg/kg were seen at this location in the past, resulted in an effort to determine

the extent of mercury in sediment around this point. Additional samples were taken late in 2014 within two locations, one upstream and one downstream, still with values above 2.0 mg/kg. Additional sampling is planned for 2015.

Water column sampling for mercury and methyl mercury was performed at 6 of 14 Peconic River sampling locations in June and July, including BNL's STP outfall. The general trend of total mercury in Peconic River water samples decreased with increasing distance downstream from the STP. Methyl mercury concentrations fluctuated between sampling periods and between both on- and off-site locations.

The Laboratory sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster interest in science. Wildlife programs are conducted at BNL in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning. In 2014, research included continued work on statistical analysis of migratory bird data and data associated with Cs-137 in deer; tracking eastern box turtles to determine home range sizes; acoustic and mist net bat surveys; impact assessments related to the construction and operation of the Long Island Solar Farm on site; and statistical analysis of long-term ecological and environmental monitoring data.

The goal of BNL's Cultural Resource Management Program is to ensure the proper stewardship of BNL and DOE historic resources. Additional goals include maintaining compliance with various historic preservation and archaeological laws and regulations, and ensuring the availability of resources to Laboratory personnel and the public for research and interpretation. Cultural resource management activities performed in 2014 included submitting a Section 106 review concerning the planned demolition of four structures on site to the New York State Historic Preservation Office (NYSHPO); loaning the Long Island History Museum materials from the Camp Upton Collection covering both World

War I and WW II for their display on “Long Island at War;” and a presentation on the ‘History of the BNL Site’ was developed and presented to BNL’s Community Advisory Council.

Chapter 6 of this report describes BNL’s natural and cultural resources in further detail.

Groundwater Protection Management Program

BNL has made significant investments in environmental protection programs over the past 20 years and continues to make progress in achieving its goal of preventing new groundwater impacts and remediating previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2014. The Laboratory’s extensive groundwater monitoring well network is used to evaluate progress in restoring groundwater quality, to comply with regulatory permit requirements, and to monitor active research and support facilities where there is a potential for environmental impact. In 2014, BNL collected groundwater samples from 756 permanent monitoring wells and 67 temporary wells during 1,737 individual sampling events.

BNL continues to make significant progress in restoring groundwater quality. During 2014, approximately 143 pounds of VOCs and approximately 1.2 mCi of Sr-90 were removed while treating almost 1.2 billion gallons of groundwater. With the treatment of approximately 23 billion gallons of groundwater since the start of active remediation in 1996, 7,276 pounds of VOCs have been removed from the aquifer, and noticeable improvements in groundwater quality are evident in a number of on- and off-site areas.

Chapter 7 of this report provides an overview of this program, and the SER Volume II, Groundwater Status Report, provides detailed descriptions, data, and maps relating to all groundwater monitoring performed in 2014.

Radiological Dose Assessment Program

The Laboratory routinely reviews its operations to ensure that any potential radiological dose to members of the public, BNL workers, visitors, and the environment is “As Low As Reasonably Achievable” (ALARA). The potential

radiological dose is calculated to the Maximally Exposed Off-Site Individual (MEOSI), which is defined as the largest possible dose to a person at a residence, office, or school beyond the BNL site boundary. For dose assessment purposes, the pathways include direct radiation exposure, inhalation, ingestion, immersion, and skin absorption. Radiological dose assessments at the Laboratory have consistently shown that the effective dose equivalent from operations is well below the EPA and DOE regulatory dose limits for the public and the environment. The dose impact from all BNL activities in 2014 was comparable to natural background radiation levels.

To measure direct radiation from Laboratory operations, 58 environmental thermoluminescent dosimeters (TLDs) were deployed, of which 9 were placed in known radiation areas and 15 off-site areas in 2014. An additional 30 TLDs were placed in a lead-shielded container for use as reference and control TLDs for comparison purposes. The average dose of all TLDs showed there was no additional contribution above the natural background radiation to on- and off-site locations from BNL operations.

The annual on-site external dose from all potential sources, including cosmic and terrestrial radiation, was estimated as 69 ± 9 mrem (690 ± 90 μ Sv) and the annual off-site external dose was estimated as 69 ± 8 mrem (690 ± 80 μ Sv). The ingestion pathway dose was estimated as 2.80 mrem (28 μ Sv) from the consumption of deer meat and $6.3\text{E-}2$ mrem (0.63 μ Sv) from consumption of fish caught in the vicinity of the Laboratory. The dose from the air inhalation pathway attributable to BNL operations was $2.85\text{E-}01$ mrem (2.9 μ Sv), which is less than 4 percent of EPA’s annual regulatory air inhalation dose limit of 10 mrem (100 μ Sv). The total dose to the MEOSI from all pathways was estimated as 3.15 mrem (32 μ Sv), which is less than 4 percent of DOE’s 100-mrem limit. Doses to aquatic and terrestrial biota and also from short-term projects, such as remediation work and waste management disposal activities, were also evaluated and found to be well below the regulatory limits.

Chapter 8 of this report describes the BNL Radiological Dose Assessment Program and monitoring data in further detail.

Quality Assurance Program

The multilayered components of the BNL Quality Assurance (QA) Program ensure that all analytical data reported in this report are reliable and of high quality, and that all environmental monitoring data meet quality assurance and quality control objectives. Samples are collected and analyzed in accordance with EPA methods and BNL standard operating procedures that are designed to ensure samples are representative and the resulting data are reliable and defensible. Quality control in the analytical laboratories is maintained through daily instrument calibrations, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated as required by project-specific quality objectives before being used to support decision making.

In 2014, the Laboratory used five off-site contract analytical laboratories to analyze environmental samples. All analytical laboratories were certified by NYSDOH for the tests they performed for BNL, and were subject to oversight that included state and national performance evaluation (PE) testing, review of QA programs, and audits.

Based on the data reviews, data validations, and results of the independent PE assessments, the chemical and radiological results documented in this report are of acceptable quality.

Chapter 9 of this report describes the BNL Quality Assurance/Quality Control Program in further detail.

Introduction

Established in 1947, Brookhaven National Laboratory is a multipurpose research institution primarily funded by the U.S. Department of Energy's Office of Science. The Laboratory is operated and managed by Brookhaven Science Associates, a partnership between the Research Foundation for the State University of New York on behalf of Stony Brook University, the largest academic user of Laboratory facilities, and Battelle, a nonprofit applied science and technology organization. BSA has been managing and operating the Laboratory under a performance-based contract with DOE since 1998. From 1947 to 1998, BNL was operated by Associated Universities, Incorporated. Prior to 1947, the site operated as Camp Upton, a U.S. Army training camp, which was active from 1917 to 1920 during World War I and from 1940 to 1946 during World War II.

One of 10 National Laboratories, BNL has a history of outstanding scientific achievements. For over 60 years, Laboratory researchers have successfully worked to envision, construct, and operate large and innovative scientific facilities in pursuit of research advances in many fields. Programs in place at BNL emphasize continual improvement in environmental, safety, security, and health performance.

1.1 LABORATORY MISSION AND POLICY

BNL's broad mission is to produce excellent science and advanced technology in a safe and environmentally sound manner with the cooperation, support, and involvement of its scientific and local communities. The fundamental elements of the Laboratory's role in support of DOE's strategic missions are the following:

- To conceive, design, construct, and operate complex, leading-edge, user-oriented research facilities in response to the needs of DOE and the international community of users.
- To carry out basic and applied research in long-term, high-risk programs at the frontier of science.
- To develop advanced technologies that address national needs and to transfer them to other organizations and to the commercial sector.
- To disseminate technical knowledge, to educate future generations of scientists and engineers, to maintain technical capabilities in the nation's workforce, and to encourage scientific awareness in the general public.

BNL's Environmental, Safety, Security, and Health (ESSH) Policy is the Laboratory's commitment to continual improvement in ESSH performance. Under this policy, the Laboratory's goals are to protect the environment, conserve resources, and prevent pollution; maintain a safe workplace by planning work and performing it safely; provide security for people, property, information, computing systems, and facilities; protect human health within our boundaries and in the surrounding community; achieve and maintain compliance with applicable ESSH requirements; maintain an open, proactive, and constructive relationship with employees, neighbors, regulators, DOE, and other stakeholders; and continually improve ESSH performance.

In 2001, BNL was the first DOE Office of Science National Laboratory to achieve full registration under the prestigious International ISO 14001 environmental management standard. In addition, in December 2006, BNL was also the first DOE Laboratory to achieve full registration under the Occupational Health and Safety

Assessment Series (OHSAS) 18001 Standard. These programs are discussed in Chapter 2 of this report.

1.2 RESEARCH AND DISCOVERIES

BNL conducts research in physics, chemistry, biology, medicine, applied science, and a wide range of advanced technologies. BNL's research facilities are also available to university, industrial, and government personnel from around the world. Current research includes energy security to help address the world's need for new, more efficient, and sustainable energy sources such as solar, wind, hydrogen, and other renewable sources; photon sciences, using ultra-bright light to reveal the structures of materials critically important to biology, technology, and more; quantum chromodynamics (QCD) to recreate matter and study the force that gives shape to visible matter in the universe from the dawn of time to today, using colliding subatomic particles; physics of the universe to explore cosmic mysteries across the smallest and largest scales imaginable, from neutrinos to dark energy; and climate, environment, and biosciences, to map climate change, greenhouse gas emissions, and plant biology to help protect our planet's future.

To date, researchers working at BNL have received seven Nobel Prizes, National Medals of Science, Enrico Fermi Awards, Wolf Foundation Prizes, R&D 100 awards, as well as other recognitions for discoveries made wholly or partly at BNL. Some significant discoveries and developments made at the Laboratory include new forms of matter, subatomic particles, technologies that fuel leading experimental programs around the world, and life-saving medical imaging techniques for diagnosis and treatment of disease.

1.3 HISTORY

BNL was founded in 1947 by the Atomic Energy Commission (AEC), a predecessor to the present DOE. AEC provided the initial funding for BNL's research into peaceful uses of the atom. The objective was to promote basic research in the physical, chemical, biological, and engineering aspects of the atomic sciences. The result was the creation of a regional laboratory to design, construct, and operate large scientific machines

that individual institutions could not afford to develop on their own.

Although BNL no longer operates any research reactors, the Laboratory's first major scientific facility was the Brookhaven Graphite Research Reactor (BGRR), which was the first reactor to be constructed in the United States following World War II. In operation from 1950 to 1968, the reactor's primary mission was to produce neutrons for scientific experimentation and to refine reactor technology. Decommissioning of the BGRR was completed in June 2012, and the remaining structures are currently undergoing long-term routine inspection and surveillance.

The High Flux Beam Reactor (HFBR) was in operation from 1965 through 1996. The facility was used solely for scientific research and provided neutrons for experiments in materials science, chemistry, biology, and physics. The HFBR also allowed researchers to study the basic nature of chemical structures, including the hydrogen bond that holds much of our world together. In late 1996, workers discovered that a leak in the HFBR spent fuel storage pool had been releasing tritium to the groundwater (see SER, Volume II, Groundwater Status Report, for further details). The reactor was shut down for routine maintenance at the time of the discovery and was never restarted. In November 1999, DOE decided that the HFBR would be permanently shut down. With input from the community, a final Record of Decision (ROD) was approved outlining the remedy for the HFBR's permanent decontamination and decommissioning (D&D).

Medical research at BNL began in 1950 with the opening of one of the first hospitals devoted to nuclear medicine. It was followed by the Medical Research Center in 1958 and the Brookhaven Medical Research Reactor (BMRR) in 1959. The BMRR was the first nuclear reactor in the nation to be constructed specifically for medical research. Due to a reduction of research funding, the BMRR was shut down in December 2000. All spent fuel from the BMRR has been removed and transported off site, and the facility is currently in a "cold" shutdown mode as a radiological facility and has entered a period of surveillance and maintenance.

The Brookhaven Linac Isotope Producer

(BLIP) has been in operation since 1972. It creates radioactive forms of ordinary chemical elements that can be used alone or incorporated into radiotracers for use in nuclear medicine research or for clinical diagnosis and treatment.

Although the Laboratory no longer performs research associated with neuroimaging, BNL's Center for Translational Neuroimaging (CTN) used brain-imaging tools, including positron emission tomography (PET) and magnetic resonance imaging (MRI) equipment, to research causes of, and treatments for, brain diseases such as drug addiction, appetite disorders, attention deficit disorder, and neurodegenerative disease. The development of PET and MRI also has helped facilitate the development of new drugs for physicians worldwide to treat patients for cancer and heart disease.

High-energy particle physics research at BNL began in 1952 with the Cosmotron, the first particle accelerator to achieve billion-electron-volt energies. Work at the Cosmotron resulted in a Nobel Prize in 1957. After 14 years of service, the Cosmotron ceased operation in 1966 and was dismantled in 1969. Knowledge gained from the Cosmotron led to design improvements and paved the way for construction of the Alternating Gradient Synchrotron (AGS). The AGS is a much larger particle accelerator, and became operational in 1960. The AGS has allowed scientists to accelerate protons to energies that have yielded many discoveries of new particles and phenomena, for which BNL researchers were awarded three Nobel Prizes. The AGS receives protons from BNL's linear accelerator (Linac), designed and built in the late 1960s as a major upgrade to the AGS complex. The Linac's purpose is to provide accelerated protons for use at AGS facilities and BLIP. The AGS booster, constructed in 1991, further enhanced the capabilities of the AGS, enabling it to accelerate protons and heavy ions to even higher energies.

The Tandem Van de Graaff accelerator began operating in 1970 and is the starting point of the chain of accelerators that provide ions of gold, other heavy metals, and protons for experiments at the Relativistic Heavy Ion Collider (RHIC). In 2010, BNL began operating a new heavy ion beam source for use by RHIC and the NASA Space Radiation Laboratory—the Electron Beam Ion Source

(EBIS). This source produces and accelerates intense and bright heavy ion beams, allowing studies with new types of ions previously unavailable from the Tandem Van de Graaff accelerator.

RHIC began operation in 2000. Inside this two-ringed particle accelerator, two beams of gold ions, heavy metals, or protons circulate at nearly the speed of light and collide, head-on, releasing large amounts of energy. RHIC is used to study what the universe may have looked like in the first few moments after its creation, offering insights into the fundamental forces and properties of matter. Planned upgrades to RHIC will expand the facility's research capabilities. The first upgrade, RHIC II, will increase the collider's collision rates and improve the sensitivity of the large detectors it uses. Another planned upgrade, the eRHIC, will add a high-energy electron ring to create the world's first electron and heavy ion collider.

The NASA Space Radiation Laboratory (NSRL) became operational in 2003. It is jointly managed by DOE's Office of Science and NASA's Johnson Space Center. The NSRL uses heavy ions extracted from the AGS booster to simulate space radiation and study the effects on biological specimens, such as cells, tissues, and DNA, as well as industrial materials. Studies are conducted to identify materials and methods that reduce the risks astronauts will face on future long-term space missions.

The National Synchrotron Light Source (NSLS) used a linear accelerator and booster synchrotron to guide charged particles in orbit inside two electron storage rings for use in a wide range of physical and biological experiments. Using beams of very intense light in the x-ray, ultraviolet, and infrared spectra, the NSLS allowed scientists to study the structure of proteins, investigate the properties of new materials, and understand the fate of chemicals in the environment. Although the NSLS had been continually updated since its commissioning in 1982, the practical limits of its performance had been reached and operations were permanently ceased in September 2014. The NSLS is currently in a transition to a safe state involving the removal of all hazardous materials in anticipation for utilization of the facility by other organizations.

To continue advances in these fields,

construction of the NSLS-II, conceived as the next generation synchrotron light source, began in 2008. To help meet the critical scientific challenges of our energy future, this new state-of-the-art, medium-energy electron storage ring synchrotron will provide x-rays more than 10,000 times brighter than the NSLS and will focus on research at the nanoscale. The NSLS-II will enable scientists to focus on some of the nation's most important scientific challenges at the nanoscale level, including clean, affordable energy, molecular electronics, and high-temperature superconductors. In October 2014, the NSLS-II achieved "first light," when the first shutter was opened to begin commissioning of the first experimental station (called a beamline) allowing powerful x-rays to travel to a phosphor detector and capture the facility's first photons. The NSLS-II is expected to be fully operational by the end of 2015.

The Laboratory's Research Support Building (RSB) was completed in 2006 and provides administrative and support functions in a single location for employees and visiting scientists. The RSB has been awarded the Leadership in Energy and Environmental Design (LEED) Silver certification from the U.S. Green Building Council. This award is based on five categories: sustainability, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.

BNL's Center for Functional Nanomaterials (CFN) provides state-of-the-art capabilities for the fabrication and study of nanoscale materials, with an emphasis on atomic-level tailoring to achieve desired properties and functions. Nanoscience has the potential to bring about and accelerate new technologies in energy distribution, drug delivery, sensors, and industrial processes. The CFN is a science-based facility used for developing strong scientific programs while offering broad access to its capabilities and collaboration through an active user program. It is one of five Nanoscale Science Research Centers funded by DOE's Office of Science, and supports the Laboratory's goal of leadership in the development of advanced materials and processes for energy applications. The CFN building has also been awarded LEED Silver certification.

The new Interdisciplinary Science Building (ISB), completed in 2013, is an energy-efficient and environmentally sustainable building that provides labs, offices, and support functions to bring together a broad spectrum of researchers, including industry, universities, and other National Laboratories. The ISB fosters energy research, focusing on the effective uses of renewable energy through improved conversion, transmission, and storage. The ISB has been awarded LEED Gold certification.

Construction of a 32-megawatt Long Island Solar Farm (LISF) at BNL was completed in the fall of 2011. The LISF is the largest solar photovoltaic (PV) electric generating plant in the Northeast region. Its goal is to help Long Island be less reliant on fossil fuel-driven power generation and to meet peak load demands from summertime air conditioning use. It is generating enough renewable energy to power approximately 4,500 homes and is helping New York State meet its clean energy and carbon reduction goals. The LISF will be one of the most studied solar installations, as it will be a focal point of the Northeast Solar Energy Research Center (NSERC) at BNL.

Construction of the NSERC is being completed in phases, as funding is available. Research will include work done at the LISF, as well as a dedicated research array for testing solar panel modules, inverters, and other equipment being developed for the solar energy industry.

1.4 FACILITIES AND OPERATIONS

Most of the Laboratory's principal facilities are located near the center of the site. The developed area is approximately 1,820 acres:

- 500 acres originally developed by the Army as part of Camp Upton, and still used for offices and other operational buildings.
- 200 acres occupied by large, specialized research facilities.
- 520 acres used for outlying facilities, such as the Sewage Treatment Plant, ecology field, housing facilities, and fire breaks.
- 400 acres of roads, parking lots, and connecting areas.
- 200 acres occupied by the Long Island Solar Farm.

The balance of the site, approximately 3,400 acres, is mostly wooded and represents the native pine barrens ecosystem.

The location of the major scientific facilities at BNL are shown on Figure 1-1. Additional facilities, shown on Figure 1-2 and briefly described below, support BNL's science and technology mission by providing basic utility and environmental services.

- *Central Chilled Water Plant.* This plant provides chilled water sitewide for air conditioning and process refrigeration via underground piping. The plant has a large refrigeration capacity and reduces the need for local refrigeration plants and air conditioning.
- *Central Steam Facility (CSF).* This facility provides high-pressure steam for facility and process heating sitewide. Either natural gas or fuel oil can be used to produce the steam, which is conveyed to other facilities through underground piping. Condensate is collected and returned to the CSF for reuse, to conserve water and energy.
- *Fire Station.* The Fire Station houses six response vehicles. The BNL Fire Rescue Group provides on-site fire suppression, emergency medical services, hazardous material response, salvage, and property protection.
- *Major Petroleum Facility (MPF).* This facility provides reserve fuel for the CSF during times of peak operation. With a total capacity of 2.3 million gallons, the MPF primarily stores No. 6 fuel oil. The 1997 conversion of CSF boilers to burn natural gas as well as oil has significantly reduced the Laboratory's reliance on oil as a sole fuel source when other fuels are more economical.
- *Sewage Treatment Plant (STP).* This plant treats sanitary and certain process wastewater from BNL facilities prior to discharge into groundwater recharge beds, similar to the operations of a municipal sewage treatment plant. The plant has a design capacity of 3 million gallons per day. Effluent is monitored and controlled under a permit issued by the New York State Department of Environmental Conservation (NYSDEC).
- *Waste Management Facility (WMF).* This facility is a state-of-the-art complex for

managing the wastes generated from BNL's research and operations activities. The facility was built with advanced environmental protection systems and features, and began operation in December 1997.

- *Water Treatment Plant (WTP).* The potable water treatment plant has a capacity of 5 million gallons per day. Potable water is obtained from five on-site wells. Water pumped from three supply wells located in the western section of the site is treated at the WTP with a lime-softening process to remove naturally occurring iron and with sodium hypochlorite for bacterial control. The plant is also equipped with dual air-stripping towers to ensure that volatile organic compounds (VOCs) are at or below New York State drinking water standards. Two wells located in the eastern section of the developed site are treated by the addition of sodium hydroxide to increase the pH of the water to make it less corrosive, and by the addition of sodium hypochlorite to control bacteria. BNL's potable water met all drinking water standards in 2014.

Past operations and research at the BNL site, dating back to the early 1940s when it was Camp Upton, have resulted in localized environmental contamination. As a result, the Laboratory was added to the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List of contaminated sites in 1989. One of 40 sites on Long Island identified for priority cleanup, BNL has made significant progress toward improving environmental operations and remediating past contamination. DOE will continue to fund cleanup projects until the Laboratory is restored and removed from the National Priorities List. Major accomplishments in cleanup activities at BNL are discussed further throughout this report.

1.5 LOCATION, LOCAL POPULATION, AND LOCAL ECONOMY

BNL is located near the geographical center of Suffolk County, Long Island, New York. The Laboratory's 5,265-acre site is located in Brookhaven Township, the largest township in both area and population, and is approximately 60 miles east of New York City. BNL is one of the

Figure 1-1. Major Scientific Facilities at BNL.

1. Relativistic Heavy Ion Collider (RHIC)	6. Heavy Ion Transfer Line (HITL)	11. National Synchrotron Light Source II (NSLS-II)
2. NASA Space Radiation Laboratory (NSRL)	7. Radiation Therapy Facility (RTF)	12. National Synchrotron Light Source (NSLS)
3. Alternating Gradient Synchrotron (AGS)	8. Scanning Transmission Electron Microscope (STEM)	13. Tandem Van de Graff and Cyclotron
4. AGS Booster	9. Interdisciplinary Science Building (ISB)	
5. Brookhaven Linac Isotope Producer (BLIP) and Linear Accelerator (Linac)	10. Center for Functional Nanomaterials (CFN)	

Figure 1-2. Major Support and Service Facilities at BNL.

five largest high-technology employers on Long Island, with approximately 3,000 employees that include scientists, engineers, technicians, and administrative personnel. In addition, the Laboratory annually hosts almost 4,000 visiting scientists and students from universities, industries, and government agencies, who often reside in apartments and dormitories on site or in nearby communities.

BNL strengthens Long Island's position as a center of innovation in energy, materials sciences, nanotechnology, and other fields crucial to the growth of New York State's economy. With a budget of more than \$650 million in 2014, the

Laboratory had a significant economic impact on New York State. In fiscal year 2014, employee salaries, wages, and fringe benefits accounted for more than \$404 million, or 62 percent, of its total budget. Supporting local and state businesses whenever possible, BNL spent more than \$60 million in 2014 on goods and services, \$30 million of that with Long Island companies.

1.6 GEOLOGY AND HYDROLOGY

BNL is situated on the western rim of the shallow Peconic River watershed. The marshy areas in the northern and eastern sections of the site are

part of the headwaters of the Peconic River. Depending on the height of the water table relative to the base of the riverbed, the Peconic River both recharges to and receives water from the underlying Upper Glacial aquifer. In times of sustained drought, the river water recharges to the groundwater; with normal to above-normal precipitation, the river receives water from the aquifer.

The terrain of the BNL site is gently rolling, with elevations varying between 44 and 120 feet above mean sea level. Depth to groundwater from the land surface ranges from 5 feet near the Peconic River to approximately 80 feet in the higher elevations of the central and western portions of the site. Studies of Long Island hydrology and geology in the vicinity of the Laboratory indicate that the uppermost Pleistocene deposits, composed of highly permeable glacial sands and gravel, are between 120 and 250 feet thick (Warren et al. 1968, Scorca et al. 1999). Water penetrates these deposits readily and there is little direct runoff into surface streams unless precipitation is intense. The sandy deposits store large quantities of water in the Upper Glacial aquifer. On average, approximately half of the annual precipitation is lost to the atmosphere through evapotranspiration, and the other half percolates through the soil to recharge the groundwater (Franke and McClymonds 1972, Aronson and Seaburn 1974).

The Long Island Regional Planning Board and Suffolk County have identified the Laboratory site as overlying a deep-flow recharge zone for Long Island groundwater (Koppelman 1978). Precipitation and surface water that recharge within this zone have the potential to replenish the Magothy and Lloyd aquifer systems lying below the Upper Glacial aquifer. It has been estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. The extent to which groundwater on site contributes to deep-flow recharge has been confirmed through the use of an extensive network of shallow and deep wells installed at BNL and surrounding areas (Geraghty & Miller 1996). This groundwater system is the primary source of drinking water for both on- and off-site private and public supply wells, and has been designated a sole source aquifer system by the Environmental Protection Agency.

The Laboratory's five in-service drinking water wells draw up to 1,000 gallons per minute, or approximately 1.34 million gallons of water per day from the aquifer to supply drinking water, process cooling water, or fire protection. This water is treated to remove contaminants and is then returned to the aquifer by way of recharge basins or injection wells. In 2014, approximately 420 million gallons of water were pumped for use on site.

Groundwater flow directions across the BNL site are influenced by natural drainage systems: eastward along the Peconic River, southeast toward the Forge River, and south toward the Carmans River (Figure 1-3). Pumping from on-site supply wells affects the direction and speed of groundwater flow, especially in the central, developed areas of the site. The main groundwater divide on Long Island is aligned generally east-west and lies approximately one-half mile north of the Laboratory. Groundwater north of the divide flows northward and ultimately discharges to the Long Island Sound. Groundwater south of the divide flows east and south, discharging to the Peconic River, Peconic Bay, south shore streams, Great South Bay, and Atlantic Ocean. The regional groundwater flow system is discussed in greater detail in *Stratigraphy and Hydrologic Conditions at the Brookhaven National Laboratory and Vicinity* (Scorca et al. 1999). In most areas at BNL, the horizontal velocity of groundwater is approximately 0.75 to 1.2 feet per day (Geraghty & Miller 1996). In general, this means that groundwater travels for approximately 20 to 22 years as it moves from the central, developed area of the site to the Laboratory's southern boundary.

1.7 CLIMATE

The Meteorological Services Group at BNL has been recording on-site weather data since 1949. The Laboratory is broadly influenced by continental and maritime weather systems. Locally, the Long Island Sound, Atlantic Ocean, and associated bays influence wind directions and humidity and provide a moderating influence on extreme summer and winter temperatures. The prevailing ground-level winds at BNL are from the southwest during the summer, from the northwest during the winter, and about equally from

those two directions during the spring and fall (Nagle 1975, 1978). Figure 1-4 shows the 2014 annual wind rose for BNL, which depicts the annual frequency distribution of wind speed and direction, measured at an on-site meteorological tower at heights of 33 feet (10 meters) and 300 feet (85 meters) above land surface.

The average monthly temperature in the area for 2014 was 50 degrees Fahrenheit (°F). The average yearly temperature for the area was 52°F. Figures 1-5 and 1-6 show the 2015 monthly mean temperatures and the historical annual mean temperatures, respectively. The total annual precipitation in 2014 was 54.25 inches. Figures

1-7 and 1-8 show the 2014 monthly and the 65-year annual precipitation data. The average snowfall for 2014 was 62.2 inches, well above the 32.50 inches average yearly snowfall for Long Island.

1.8 NATURAL RESOURCES

The Laboratory is located in the oak/chestnut forest region of the Coastal Plain and constitutes about 5 percent of the 100,000-acre New York State-designated region on Long Island known as the Central Pine Barrens. The section of the Peconic River running through BNL is designated as “scenic” under the New York State Wild,

Figure 1-3. BNL Groundwater Flow Map.

Explanation: Wind direction was measured at heights of 10 and 85 meters above the ground, for a total of 520,064 measurements at each height. The readings were plotted on the charts to indicate how often wind came from each direction. The concentric circles represent multi-percentage increases in the frequency. For example, at 10 meters above the ground, wind was from due south 5 percent of the time. The predominant wind direction in 2014 was from the northwest at the 10-m level, and from the southwest at the 88-m level.

Figure 1-4. BNL Wind Rose (2014).

Figure 1-5. BNL 2014 Monthly Mean Temperature versus 65-Year Monthly Average.

Figure 1-6. BNL 2014 Annual Mean Temperature Trend (65 Years).

Figure 1-7. BNL 2014 Monthly Precipitation versus 65-Year Monthly Average.

Figure 1-8. BNL 2014 Annual Precipitation Trend (65 Years).

Scenic, and Recreational River System Act of 1972. Due to the general topography and porous soil, the land is very well drained and there is little surface runoff or open standing water. However, depressions form numerous small, pocket wetlands with standing water on a seasonal basis (vernal pools), and there are six regulated wetlands on site. Thus, a mosaic of wet and dry areas correlates with variations in topography and depth to the water table.

Vegetation on site is in various stages of succession, which reflects a history of disturbances to the area. For example, when Camp Upton was constructed in 1917, the site was entirely cleared of its native pines and oaks. Although portions of the site were replanted in the 1930s, portions were cleared again in 1940 when Camp Upton was reactivated by the U.S. Army. Other past disturbances include fire, local flooding, and draining. Current operations minimize disturbances to the more natural areas of the site.

More than 200 plant, 15 animal, 85 bird, 13 amphibian, 12 reptile, and 10 fish species have been identified on site, some of which are New York State threatened, endangered, exploitably vulnerable, and species of special concern. To eliminate or minimize any negative effects that BNL operations might cause to these species, precautions are in place to protect habitats and natural resources at the Laboratory.

In November 2000, DOE established the Upton Ecological and Research Reserve at BNL. The 530-acre Upton Reserve (10 percent of the Laboratory's property) is on the eastern portion of the site, in the Core Preservation Area of the Central Pine Barrens. The Upton Reserve creates a unique ecosystem of forests and wetlands that provides habitats for plants, mammals, birds, reptiles, and amphibians. From 2000 to 2004, funding provided by DOE under an Inter-Agency Agreement between DOE and the U.S. Fish & Wildlife Services was used to conduct resource management programs for the conservation, enhancement, and restoration of wildlife and habitat in the reserve. In 2005, management was transitioned to the Foundation for Ecological Research in the Northeast (FERN). Management of the Upton Reserve falls within the scope of BNL's Natural Resource Management Plan, and

the area will continue to be managed for its key ecological values and as an area for ecological research (BNL 2011). Additional information regarding the Upton Reserve and the Laboratory's natural resources can be found in Chapter 6 of this report.

1.9 CULTURAL RESOURCES

The Laboratory is responsible for ensuring compliance with historic preservation requirements. BNL's Cultural Resource Management Plan was developed to identify, assess, and document the Laboratory's historic and cultural resources (BNL 2012). These resources include World War I trenches; Civilian Conservation Corps features; World War II buildings; and historic structures, programs, and discoveries associated with high-energy physics, research reactors, and other science conducted at BNL. The Laboratory currently has three facilities classified as eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor complex, the High Flux Beam Reactor complex, and the World War I training trenches associated with Camp Upton. Further information can be found in Chapter 6.

CHAPTER 1: INTRODUCTION

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Environmental Management System

One of Brookhaven National Laboratory's highest priorities is ensuring that its commitment to environmental protection is as strong as its passion for discovery. Brookhaven Science Associates (BSA), the contractor operating the Laboratory on behalf of DOE, takes environmental stewardship very seriously. As part of its commitment to environmentally responsible operations, BSA has established the BNL Environmental Management System (EMS).

An EMS ensures that environmental issues are systematically identified, controlled, and monitored. Moreover, an EMS provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement. The Laboratory's EMS was designed to meet the rigorous requirements of the globally recognized International Organization for Standardization (ISO) 14001 Environmental Management Standard, with additional emphasis on compliance, pollution prevention, and community involvement. Annual audits are required to maintain an EMS registration, and recertification audits of the entire EMS occur every 3 years. In 2014, an EMS surveillance audit determined that BNL remains in conformance with the ISO 14001: 2004 Standard.

In 2014, the Laboratory continued its strong support of the BNL Pollution Prevention Program, which seeks ways to eliminate waste and toxic materials. Pollution prevention projects resulted in more than \$4.09 million in cost avoidance or savings and resulted in the reduction or reuse of approximately 35.5 million pounds of waste. Also in 2014, the BNL Pollution Prevention Program funded two new proposals, investing approximately \$9,000. Anticipated annual savings from these projects are estimated at approximately \$10,000, for an average payback period of slightly less than one year. The ISO 14001-registered EMS and the nationally recognized Pollution Prevention Program continue to contribute to the Laboratory's success in promoting pollution prevention.

BNL continues to address legacy environmental issues, and openly communicates with neighbors, regulators, employees, and other interested parties on environmental issues and cleanup progress on site.

2.1 INTEGRATED SAFETY MANAGEMENT, ISO 14001, AND OHSAS 18001

The Laboratory's Integrated Safety Management System (ISMS) integrates environment, safety, and health management into all work planning and execution. The purpose of BNL's ISMS is to ensure that all work integrates DOE's five Core Functions and seven Guiding Principles into all work processes. The five

Core Functions, as defined by DOE P 450.4, Safety Management System Policy, are:

- **DEFINE THE SCOPE OF WORK:** Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.
- **IDENTIFY AND ANALYZE HAZARDS ASSOCIATED WITH THE WORK:** Hazards associated with the work are identified, analyzed, and categorized.

- **DEVELOP AND IMPLEMENT HAZARD CONTROLS:** Applicable standards and requirements are identified and agreed upon, controls to prevent/mitigate hazards are identified, the safety envelope is established, and controls are implemented.
- **PERFORM WORK WITHIN CONTROLS:** Readiness is confirmed and work is performed safely.
- **PROVIDE FEEDBACK ON ADEQUACY OF CONTROLS AND CONTINUE TO IMPROVE SAFETY MANAGEMENT:** Feedback information on the adequacy of controls is gathered; opportunities for improving the definition and planning of work are identified and implemented; line and independent oversight is conducted; and, if necessary, regulatory enforcement actions occur.

The seven Guiding Principles, also as defined by DOE P 450.4, are:

- **LINE MANAGER CLEARLY RESPONSIBLE FOR SAFETY:** Line management is directly responsible for the protection of the public, the workers, and the environment.
- **CLEAR ROLES AND RESPONSIBILITIES:** Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels.
- **COMPETENCE COMMENSURATE WITH RESPONSIBILITIES:** Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
- **BALANCED PRIORITIES:** Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.
- **IDENTIFY SAFETY STANDARDS AND REQUIREMENTS:** Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards and requirements shall be established which, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.

- **HAZARD CONTROLS TAILORED TO WORK BEING PERFORMED:** Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and associated hazards.
- **OPERATIONS AUTHORIZATION:** The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

The integrated safety processes within ISMS contributed to BNL achieving ISO 14001 and Occupational Health and Safety Assessment Series (OHSAS) 18001 registrations.

The ISO 14001 Standard is globally recognized and defines the structure of an organization's EMS for purposes of improving environmental performance. OHSAS 18001 mirrors the ISO 14001 structure for purposes of improving safety and providing a safe and healthy workplace, free from recognized hazards for all operations. The process-based structure of the ISO 14001 and OHSAS 18001 Standards are based on the "Plan-Do-Check-Act" improvement cycle. Both standards require an organization to develop a policy, create plans to implement the policy, implement the plans, check progress and take corrective actions, and review the system periodically to ensure its continuing suitability, adequacy, and effectiveness.

The Laboratory's EMS, as a whole, was officially registered to the ISO 14001 Standard in July 2001, and was the first DOE Office of Science Laboratory to obtain third-party registration to this environmental standard. BNL was officially registered to the OHSAS 18001 Standard in 2006, and was again the first DOE Office of Science Laboratory to achieve this registration. Each certification requires the Laboratory to undergo annual audits by an accredited registrar to assure that the systems are maintained.

An ISO 14001 and OHSAS 18001 surveillance audit was conducted by auditors from NSF International Strategic Registrations in June 2014 (OHSAS 18001 results are not included in this report). The audit identified one nonconformance in BNL's Cultural Resource program involving tagging of artifacts that are part of the Historical Resource Identification Tag Program.

2.2 ENVIRONMENTAL, SAFETY, SECURITY, AND HEALTH POLICY

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of an organization. BNL's environmental commitments are incorporated into a comprehensive ESSH Policy. The policy, issued and signed by the Laboratory Director, makes clear the Laboratory's commitment to environmental stewardship, the safety of the public and BNL employees, and the security of the site. The policy continues as a statement of the Laboratory's intentions and principles regarding overall environmental performance. It provides a framework for planning and action and is included in employee, guest, and contractor training programs. The ESSH Policy is posted throughout the Laboratory and on the BNL website at <http://www.bnl.gov>. The goals and commitments focusing on compliance, pollution prevention, community outreach, and continual improvement include:

- **ENVIRONMENT:** We protect the environment, conserve resources, and prevent pollution.
- **SAFETY:** We maintain a safe workplace, and we plan our work and perform it safely. We take responsibility for the safety of ourselves, coworkers, and guests.
- **SECURITY:** We protect people, property, information, computing systems, and facilities.
- **HEALTH:** We protect human health within our boundaries and in the surrounding community.
- **COMPLIANCE:** We achieve and maintain compliance with applicable ESSH requirements.
- **COMMUNITY:** We maintain open, proactive, and constructive relationships with our employees, neighbors, regulators, DOE, and other stakeholders.
- **CONTINUAL IMPROVEMENT:** We continually improve ESSH performance.

2.3 PLANNING

The planning requirements of the ISO 14001 Standard require BNL to identify the environmental aspects and impacts of its activities, products, and services; to evaluate applicable legal and other requirements; to establish objectives and targets; and to create action plans to achieve the objectives and targets.

2.3.1 ENVIRONMENTAL ASPECTS

An "environmental aspect" is any element of an organization's activities, products, and services that can impact the environment. As required by the ISO 14001 Standard, BNL evaluates its operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant. The Laboratory's criteria for significance are based on actual and perceived impacts of its operations and on regulatory requirements.

BNL utilizes several processes to identify and review environmental aspects. Key among these is the Process Assessment Procedure. This is an evaluation that is documented on a Process Assessment Form, which consists of a written process description, a detailed process flow diagram, a regulatory determination of all process inputs and outputs, identification of pollution prevention opportunities, and identification of any assessment, prevention, and control measures that should be considered.

Environmental professionals work closely with Laboratory personnel to ensure that environmental requirements are integrated into each process. Aspects and impacts are evaluated annually to ensure that they continue to reflect stakeholder concerns and changes in regulatory requirements.

2.3.2 Legal and Other Requirements

To implement the compliance commitments of the ESSH Policy and to meet its legal requirements, BNL has systems in place to review changes in federal, state, or local environmental regulations and to communicate those changes to affected staff. Laboratory-wide procedures for documenting these reviews and recording the actions required to ensure compliance are available to all staff through BNL's web-based Standards-Based Management System (SBMS) subject areas.

Signed in 2009, Executive Order (EO) 13514, Federal Leadership in Environmental, Energy, and Economic Performance, establishes sustainability goals for federal agencies and focuses on improving their environmental, energy, and economic performance. In addition to guidance, recommendations, and plans, which are due by

specific sustainability due dates, EO 13514 has set numerical targets for agencies.

Each governmental facility is required to have a Site Sustainability Plan (SSP) in place detailing the strategy for achieving these long-term goals, and to provide an annual status. The requirements will influence the future of the Laboratory's EMS program and most have already been incorporated into BNL's SSP. Table 2-1 identifies the EO goal, the actions contained in the SSP, and the Laboratory's performance in 2014.

2.3.3 Objectives and Targets

The establishment of environmental objectives and targets is accomplished through a Performance-Based Management System. This system is designed to develop, align, balance, and implement the Laboratory's strategic objectives, including environmental objectives. The system drives BNL's improvement agenda by establishing a prioritized set of key objectives, called the Performance Evaluation Management Plan. BSA works closely with DOE to clearly define expectations and performance measures. Factors for selecting environmental priorities include:

- Meeting the intent and goals of EO 13514.
- Significant environmental aspects.
- Risk and vulnerability (primarily, threat to the environment).
- Legal requirements (laws, regulations, permits, enforcement actions, and memorandums of agreement).
- Commitments (in the ESSH Policy) to regulatory agencies, and to the public.
- Importance to DOE, the public, employees, and other stakeholders.

Laboratory-level objectives and targets are developed on a fiscal year (FY) schedule. For FY 2014, BNL's environmental objective included maintaining ISO 14001 and OHSAS 18001 certifications.

2.3.4 Environmental Management Programs

Each organization within BNL develops an action plan detailing how they will achieve their environmental objectives and targets, as well as how they commit the resources necessary to successfully implement both Laboratory-wide

and facility-specific programs. BNL has a budgeting system designed to ensure that priorities are balanced and to provide resources essential to the implementation and control of the EMS. The Laboratory continues to review, develop, and fund important environmental programs to further integrate environmental stewardship into all facets of its missions.

2.3.4.1 Compliance

BNL has an extensive program to ensure that the Laboratory remains in full compliance with all applicable environmental regulatory requirements and permits. Legislated compliance is outlined by the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAPs), Clean Water Act (e.g., State Pollutant Discharge Elimination System [SPDES]), Safe Drinking Water Act (SDWA), Resource Conservation and Recovery Act (RCRA), and other programs. Other compliance initiatives at the Laboratory involve special projects, such as upgrading petroleum and chemical storage tank facilities, upgrading the sanitary sewer system, closing underground injection control devices, retrofitting or replacing air conditioning equipment refrigerants, and managing legacy facilities. (See Chapter 3 for a list of regulatory programs to which BNL subscribes, and a thorough discussion of these programs and their status.)

2.3.4.2 Groundwater Protection

BNL's Groundwater Protection Program is designed to prevent negative impacts to groundwater and to restore groundwater quality by integrating pollution prevention efforts, monitoring, groundwater restoration projects, and communicating performance. The Laboratory has developed a Groundwater Protection Contingency Plan that defines an orderly process for quickly verifying the results and taking corrective actions in response to unexpected monitoring results (BNL 2013c). Key elements of the groundwater program are full, timely disclosure of any off-normal occurrences, and regular communication on the performance of the program. Chapter 7 and SER Volume II, Groundwater Status Report, provide additional details about this program, its performance, and monitoring results for 2014.

CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2014.

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Goal 1: Greenhouse Gas (GHG) Reduction		
28 percent Scope 1 and 2 GHG reduction by FY 2020 from a FY 2008 baseline (2014 target: 19 percent).	<ul style="list-style-type: none"> The FY 2008 baseline was 205,628 MtCO₂e. In FY 2014, BNL's Scope 1 and 2 GHG emissions totaled 131,422 MtCO₂e—a decrease of 36.1 percent against the FY 2008 baseline. This total is in accordance with the Consolidated Energy Data Report. However, this value does not reflect adjustments by the Sustainable Performance Office for the Long Island Solar Farm (LISF). BNL estimates the total FY14 GHG value to be approximately 95,500 MtCO₂e. 	<ul style="list-style-type: none"> Continuing efforts in FY 2014 included hydropower, the Long Island Solar Farm (LISF), on-site photovoltaic (PV) research and development, Renewable Energy Credit (REC) purchases, and energy intensity reduction through the Utility Energy Services Contract (UESC) Phase I. A study was initiated to determine how a UESC could be used to finance a "right-sized" Combined Heat and Power (CHP) at BNL. Preliminary audits by two energy services companies (ESCOs) are underway for potential Phase II work.
13 percent Scope 3 GHG reduction by FY 2020 from a FY 2008 baseline (2014 target: 5 percent).	<ul style="list-style-type: none"> Overall, Scope 3 GHG emissions have been reduced by 13.58 percent from the FY 2008 baseline of 20,136 MtCO₂e to 17,401 MtCO₂e in FY 2014. Emissions specifically from employee business travel have increased by 2.2 percent from 8,800 MtCO₂e in FY 2008 to 8,995 MtCO₂e in FY 2014. 	<ul style="list-style-type: none"> Further improvements in metrics for measuring commuting GHG reductions. Expanding teleconferencing capabilities through the deployment of enhanced communication technologies during site-wide telephone replacement. Converting the current Rideshare website to a Commuter Choice website and adding new intranet links to other BNL web locations to expand visibility and accessibility. Identifying steps necessary to retrieve accurate counts of exempt and nonexempt monthly employees working 4-day, 40-hour and 9-day, 80-hour compressed work schedules, as well as the number of telework days from PeopleSoft HR time reporting records. Changing the standard allowable rental in domestic and foreign travel standard procedures from a mid-size to a compact vehicle.
Goal 2: Sustainable Buildings		
30 percent energy intensity BTU/GSF (British Thermal Units Per Gross Square Foot) reduction by FY 2015 from a FY 2003 baseline (2014 target: 27 percent).	<ul style="list-style-type: none"> BNL's FY 2014 energy intensity was 251,094 Btu/GSF. This level represents a cumulative reduction of 22.4 percent from the FY 2003 baseline of 323,780 Btu/GSF. UESC effort was 50 percent complete by the end of 2014. 	<ul style="list-style-type: none"> The Utility Energy Services Contract was awarded on October 22, 2013. Phase I implementation was approximately 50 percent complete as of late 2014. It is estimated to result in an approximate 11 percent reduction in energy intensity. Energy conservation measures include improving the efficiency of supplying chilled water, lighting upgrades throughout the Laboratory, and installation of building controls with enhanced temperature setback. Further UESC Phases and other planned initiatives include providing "free" cooling, improving the steam system, and CHP. Preliminary audits are underway. Presentations to BNL complexes and facility managers will begin in late fall 2015 to emphasize the importance of building temperature setback.
Energy Independence and Security Act Section 432 energy and water evaluations.	<ul style="list-style-type: none"> 100 percent completed within last 4 years. 	<ul style="list-style-type: none"> Green Energy Surveys are in process and on schedule. 25 percent of Laboratory buildings were surveyed by VFA in FY 2014. The reporting format has been revised to better emphasize potential energy projects.

(continued on next page)

CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2014 (continued).

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Individual buildings metering for 90 percent of electricity (by October 1, 2012); for 90 percent of steam, natural gas, and chilled water (by October 1, 2015). (2014 status: 90 percent and 75 percent, respectively).	<ul style="list-style-type: none"> The status of individual building metering is as follows: electric: 97 percent; natural gas: 100 percent; steam: 85 percent; and chilled water: 100 percent. 17 Ethernet-based Power Quality meters were installed throughout the Laboratory. 5 steam meters were upgraded to the advanced metering platform. Chilled water metering in the National Synchrotron Light Source-II includes segregated metering for the ring/process loads and the laboratory-office buildings cooling loads Advanced potable water metering has been installed in the Interdisciplinary Science Building-1. A new chilled water meter for Data Center 515 has been installed and is operating. 	<ul style="list-style-type: none"> Additional meter installations are on-going. The Laboratory is investigating the need for additional sub-meters for and IT loads that are not on the uninterruptable power circuits. A potential project to relocate/consolidate BNL data centers provides an opportunity to improve data center performance and metering.
Cool roofs, unless uneconomical, for roof replacements unless project already has CD-2 approval. New roofs must have thermal resistance of at least R-30.	<ul style="list-style-type: none"> Unless uneconomical, all roof replacements are designed and constructed in accordance with the requirements for cool roofs. 	<ul style="list-style-type: none"> Roof repairs and replacements will be performed at Buildings 510, 624, and 725. Meeting the cool roof requirements will be performed during the design phase.
15 percent of existing buildings greater than 5,000 gross square feet (GSF) are compliant with the Guiding Principles of High Performance and Sustainable Buildings (HPSB) by FY 2015 (2014 target: 13 percent).	<ul style="list-style-type: none"> The Modernization Project Office continues to make progress towards the 15 percent requirement. At the end of FY 2014, BNL is 85 percent HPSB compliant for 10 buildings that will not achieve Leadership in Energy and Environmental Design (LEED) certification. Tasks completed in FY 2014 include HPSB upgrades at Building 599, re-evaluation of Building 98 for HPSB compliance, and the commencement of the roof replacement at Building 438. 	<ul style="list-style-type: none"> Complete remaining work to meet the 15 percent milestone. Activities include Building 860 RTU and duct replacement, Building 98 miscellaneous tasks, remaining retro commissioning, and finalization of procedure and policy changes.
All new construction, major renovations, and alterations of buildings greater than 5,000 gross square feet must comply with Guiding Principles.	<ul style="list-style-type: none"> All recently completed projects obtained LEED certifications 	<ul style="list-style-type: none"> HPSB requirements will be included in the conceptual design for the Building 725 renovation.
Efforts to increase regional and local planning coordination and involvement.	<ul style="list-style-type: none"> BNL continues to investigate public transportation and increased carpool ridership. Local renewable energy is supported through the Long Island Solar Farm and the Northeast Solar Energy Research Center. Natural resource activities include measuring the impact of large-scale solar installations. 	<ul style="list-style-type: none"> The Laboratory will continue to support federal and local efforts to reduce reliance on petroleum by establishing a working group to reduce single occupancy vehicles and examining alternate work schedules in FY 2015. The Laboratory will implement the deer management program and re-deploy tick management techniques in FY 2015. The Laboratory will continue to host conferences and attend meetings to promote the BNL's renewable energy strategies in FY 2015.
Goal 3: Fleet Management		
10 percent annual increase in fleet alternative fuel consumption by FY 2015 relative to a FY 2005 baseline (2014 target: 136 percent cumulative since 2005).	<ul style="list-style-type: none"> Based on Fleet Automotive Statistical Tool (FAST) data, the total annual alternative fuel consumption is: <ul style="list-style-type: none"> -FY 2012: 36,416 gas gallon equivalent (gge) -FY 2013: 43,563 gge -FY 2014: 51,449 gge 	<ul style="list-style-type: none"> BNL plans to convert to General Services Administrative (GSA) leasing, which will replace older gasoline vehicles with alternative fuel vehicles.

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CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2014 (continued).

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
2 percent annual reduction in fleet petroleum consumption by FY 2020 relative to a FY 2005 baseline (2014 status: 18 percent cumulative since 2005).	<ul style="list-style-type: none"> Based on FAST data, the total annual petroleum consumption is: <ul style="list-style-type: none"> -FY 2012: 80,418 gge -FY 2013: 71,865 gge -FY 2014: 61,110 gge 	<ul style="list-style-type: none"> BNL plans to convert to GSA leasing, which will replace older gasoline vehicles with alternative fuel vehicles.
100 percent of light duty vehicle purchases consist of alternative fuel vehicles (AFV) by FY 2015 and thereafter (75 percent by FY 2000-2015).	<ul style="list-style-type: none"> All purchases are alternative fuel vehicles where available. 	<ul style="list-style-type: none"> GSA leasing can provide 100 percent of light duty vehicles as alternative fuel vehicles.
Goal 4: Water Use Efficiency and Management		
26 percent potable water intensity (gallons per gross square foot) reduction by FY 2020 from a FY 2007 baseline (2014 target: 14 percent).	<ul style="list-style-type: none"> Annual water use intensity has decreased from 101.2 gallons per gross square foot to 89.1 gallons per gross square foot, an 11.9 percent water usage reduction since base year 2007. 	<ul style="list-style-type: none"> The Laboratory will continue to implement BNL's Water Management Plan. New construction and renovation will utilize water-efficient processes and plumbing fixtures to conserve water. Increased science activities that involve accelerator cooling due to using cooling tower evaporation are expected to increase water use.
20 percent water consumption (gallons) reduction of industrial, landscaping, and agricultural (ILA) water by FY 2020 from a FY 2010 baseline (2014 target: 8 percent).	<ul style="list-style-type: none"> No permanent landscaping or agricultural water use. 	<ul style="list-style-type: none"> No actions are planned.
Goal 5: Pollution Prevention and Waste Reduction		
Divert at least 50 percent of non-hazardous solid waste, excluding construction and demolition debris by FY 2015.	<ul style="list-style-type: none"> Over the past 13 years, BNL's annual diversion rate of non-hazardous solid waste has been above the 50 percent baseline level prescribed by the Executive Order, ranging between 54 percent and 68 percent. During FY 2014, the recycling rate was approximately 66 percent. 	<ul style="list-style-type: none"> BNL will continue to divert non-hazardous solid waste at or above the 50 percent baseline level, as well as focus on educating employees on the Laboratory's recycling programs. Continuing with past tradition, the P2 Program will also solicit ideas for partial or full funding of projects that minimize waste or help prevent pollution.
Divert at least 50 percent of construction and demolition debris by FY 2015.	<ul style="list-style-type: none"> BNL recycles 95 percent of construction, demolition, and woody debris. 	<ul style="list-style-type: none"> Construction materials will continue to be sent to the Construction & Demolition (C&D) transfer station for sorting and recycling. Concrete, stone, and brick demolition debris will continue to be converted into recycled concrete aggregate (RCA) via a concrete crusher.
Goal 6: Sustainable Acquisition		
Procurements meet requirements by including necessary provisions and clauses in 95 percent of applicable contracts.	<ul style="list-style-type: none"> The requirement for Sustainable Acquisition are incorporated into all of BNL's Terms and Conditions issued by the Property and Procurement Division. 	<ul style="list-style-type: none"> The following actions are planned for FY15 and beyond: (1) develop awareness training for green products for Material Coordinators; (2) provide technical assistance and education to the Laboratory community on the use and availability of green products and services; (3) increase communication on Sustainable Acquisition through Lessons Learned and success stories; and (4) continue to modify the Laboratory's E-Procurement (E-Pro) system to increase green purchasing.
Goal 7: Electronic Stewardship and Data Centers		
All data centers are metered to measure a monthly Power Utilization Effectiveness (PUE) of 100 percent by FY 2015 (2014 status: 90 percent).	<ul style="list-style-type: none"> Initial PUE study indicated current PUE to be above 1.6. Additional electric meters and one new chilled water meter installed in FY 2014. Continued effort to identify and install additional metering so that a more accurate PUE for each data center may be measured and monitored. 	<ul style="list-style-type: none"> BNL is investigating the need for additional sub-meters for any IT loads that are not on the uninterruptible power circuits.

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Table 2-1. EO 13514 Goals: Status Summary for Fiscal Year (FY) 2014. *(concluded)*.

DOE Goal	BNL Performance Status	BNL Planned Actions and Contributions
Core data centers maximum annual weighted average PUE of 1.4 by FY 2015 (2014 status: 1.5 percent).	<ul style="list-style-type: none"> The most recent evaluation of the main data center calculates the PUE at 1.79 for FY 2014. The small data center in Building 459 had a PUE of 2.1. 	<ul style="list-style-type: none"> A potential project to relocate/consolidate BNL data centers provides an opportunity to improve data center performance and metering.
Power Management - 100 percent of eligible PCs, laptops, and monitors with power management actively implemented and in use by FY 2012.	<ul style="list-style-type: none"> All systems in the BNL domain that are capable of power management have the setting enabled. 	<ul style="list-style-type: none"> BNL will continue to evaluate the feasibility of extending this desktop computer-power management policy to other operating systems.
Electronic Stewardship - 95% of eligible electronics acquisitions meet EPEAT standards	<ul style="list-style-type: none"> In FY 2014, the contract governing the procurement of printers, laptops, and desktop computers ordered through the BNL E-Procurement system required that they have an EPEAT "Gold" certification. 	<ul style="list-style-type: none"> The Laboratory will continue to require that all printers, laptops, and desktop computers ordered through the E-Procurement System have an EPEAT "Gold" certification.
Goal 8: Renewable Energy		
20 percent of annual electricity consumption from renewable sources by FY 2020 (2014 target: 7.5 percent).	<ul style="list-style-type: none"> BNL purchased 40 million kWh of renewable energy credits, which equals approximately 9 percent of the Laboratory's total usage of electric and thermal energy. The on site Long Island Solar Farm began operations November 2011, and in FY 2013, provided 52 million kWh/year of clean renewable energy to Long Island. The on-site NSERC solar array became operational in May 2014. Once fully built, the annual output is estimated at approximately 7000,000 kWh. 	<ul style="list-style-type: none"> A commercial evaluation of the 2013 CHP/biomass study was initiated in FY 2014 to further determine the viability of CHP at BNL; it will be completed in early 2015. REC purchases will continue and the quantity will need to be significantly increased due to the 20 percent requirement.

2.3.4.3 Waste Management

As a byproduct of the world-class research it conducts, BNL generates a wide range of wastes. These wastes include materials common to many businesses and industries, such as office wastes (e.g., paper, plastic, etc.), aerosol cans, batteries, paints, and oils. However, the Laboratory's unique scientific activities also generate "specialized" waste streams that are subject to additional regulation and special handling, including radioactive, hazardous, and mixed waste. BNL's Waste Management Facility (WMF), operated by the Environmental Protection Division (EPD), is responsible for collecting, storing, transporting, and managing the disposal of these specialized wastes. This modern facility was designed for handling hazardous, industrial, radioactive, and mixed waste and is comprised of two staging areas: a facility for hazardous waste and mixed waste (both hazardous and radioactive) in Building 855,

regulated by RCRA, and a reclamation building for radioactive material in Building 865. The RCRA building is managed under a permit issued by the New York State Department of Environmental Conservation (NYSDEC). These buildings are used for short-term storage of waste before it is packaged or consolidated for off-site shipment to permitted treatment and disposal facilities. Due to the relatively small quantities and infrequent generation of mixed waste, BNL has reduced its waste storage footprint by consolidating hazardous and mixed wastes into its RCRA waste building.

In 2014, BNL generated the following types and quantities of waste from routine operations:

- Hazardous waste: 4.3 tons
- Mixed waste: 96 ft³
- Radioactive waste: 3,261 ft³

Hazardous waste from routine operations in 2014 increased from 2013 generation rates, as shown in Figure 2-1a. This was not attributed

to any one source, but rather due to small increases in generation throughout the Laboratory. Mixed waste generation remained relatively steady from 2013 rates, as shown in Figure 2-1b. As shown in Figure 2-1c, the radioactive waste quantity for routine operations increased from 2013 rates, which is primarily attributed to increased operations at the BNL's accelerator facilities. Routine operations are defined as ongoing industrial and experimental operations.

Wastes generated by remediation projects, facility decommissioning activities, or one-time events (e.g., lab cleanouts) are considered non-routine. In 2014, BNL continued to reduce the inventory of legacy waste materials through laboratory cleanouts. Wastes from facility decommissioning activities included some remaining debris and equipment from the former Hot Shop and former Brookhaven Medical Research Reactor (BMRR). Other non-routine wastes included the disposal of lead-contaminated debris, lead shielding, and polychlorinated biphenyl (PCB) wastes.

Figures 2-1d through 2-1f show wastes generated from non-routine operations. Waste generation from these activities has varied significantly from year to year. This is expected, as various decommissioning and remedial actions are conducted.

2.3.4.4 Pollution Prevention and Waste Minimization

The BNL Pollution Prevention (P2) Program is an essential element for the successful accomplishment of the Laboratory's broad mission. The P2 Program reflects national and DOE pollution prevention goals and policies, and represents an ongoing effort to make pollution prevention and waste minimization an integral part of BNL's operating philosophy.

Pollution prevention and waste reduction goals have been incorporated into the DOE contract with BSA, into BNL's ESSH Policy, the Performance Evaluation Management Plan associated with the Laboratory's operating contract with DOE, and BNL's SSP. Key elements of the P2 Program include:

- Eliminate or reduce emissions, effluents, and waste at the source where possible, and ensure that they are "as low as reasonably achievable".
- Procure environmentally preferable products (known as "affirmative procurement").
- Conserve natural resources and energy.
- Reuse and recycle materials.
- Achieve or exceed BNL/DOE waste minimization, P2, recycling, and affirmative procurement goals.
- Comply with applicable requirements (e.g., New York State Hazardous Waste Reduction Goal, Executive Orders, etc.).
- Reduce waste management costs.
- Implement P2 projects.
- Improve employee and community awareness of P2 goals, plans, and progress.

The BNL P2 and recycling programs have achieved significant reductions in waste generated by routine operations, as shown in Figures 2-1a through 2-1c. This continues a positive trend, and is further evidence that pollution prevention planning is well integrated into the Laboratory's work planning process. These positive trends are also driven by the EMS emphasis on preventing pollution and establishing objectives and targets to reduce environmental impacts. Table 2-2 describes the P2 projects implemented through 2014, and provides the number of pounds of materials reduced, reused, or recycled, as well as the estimated cost benefit of each project.

The implementation of pollution prevention opportunities, recycling programs, and conservation initiatives has significantly reduced both waste volumes and management costs. In 2014, these efforts resulted in more than \$4.09 million in cost avoidance or savings and approximately 35.5 million pounds of materials being reduced, recycled, or reused annually. BNL's biggest pollution prevention project in 2014 was the kickoff of the Utility Energy Services Contract (UESC), which included energy-efficient lighting, new building controls and commissioning, and an energy-efficient chiller project.

The Laboratory also has an active and successful solid waste recycling program, which involves all employees. In 2014, BNL collected approximately 150 tons of office paper for recycling. Cardboard, bottles and cans, construction debris, motor oil, scrap metals, lead, automotive batteries, electronic scrap, fluorescent

light bulbs, and drill press/machining coolant were also recycled. Table 2-3 shows the total number of tons (or units) of the materials recycled.

2.3.4.5 Water Conservation

BNL's water conservation program has achieved dramatic reductions in water use since the mid 1990s. The Laboratory continually evaluates water conservation as part of facility upgrades or new construction initiatives. These efforts include more efficient and expanded use of chilled water for cooling and heating/ventilation and air conditioning (HVAC) systems, and reuse of once-through cooling water for other systems, such as cooling towers. Through an annual maintenance program, conventional plumbing fixtures are replaced with low-flow devices.

The Laboratory's goal is to reduce the consumption of potable water and reduce the possible impact of clean water discharges on Sewage Treatment Plant (STP) operations. Figure 2-2 shows the 14-year trend of water consumption. Total water consumption in 2014 was approximately 3 percent higher than in 2013. This minor increase can be attributed to an increase in process cooling that utilize cooling towers. In each of the past 9 years, the water consumption total was approximately half the 1999 total—a reduction of nearly a half-billion gallons per year.

Figure 2-1a. Hazardous Waste Generation from Routine Operations, 1998 – 2014.

Figure 2-1b. Mixed Waste Generation from Routine Operations, 1998 – 2014

Figure 2-1c. Radioactive Waste Generation from Routine Operations, 1998 – 2014.

Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 1998 – 2014.

Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 1998 – 2014.

Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 1998 – 2014.

2.3.4.6 Energy Management and Conservation

Since 1979, the Laboratory's Energy Management Group has been working to reduce energy use and costs by identifying and implementing cost-effective, energy-efficient projects; monitoring energy use and utility bills; and assisting in obtaining the least expensive energy sources possible. The group is responsible for developing, implementing, and coordinating BNL's energy management efforts and assisting DOE in meeting the energy and sustainability goals in EO 13514; DOE Order 436.1, Departmental Sustainability; and the Secretary's initiatives. The Laboratory's SSP addresses all aspects of the DOE energy, water, transportation, and other sustainability goals.

BNL has more than 4.9 million square feet of building space. Many scientific experiments at the Laboratory use particle beams generated and accelerated by electricity, with the particles controlled and aligned by large electromagnets. In 2014, BNL used approximately 291 million kilowatt hours (kWh) of electricity, 102,000 gallons of fuel oil, 19,000 gallons of propane, and 670 million ft³ of natural gas.

Fuel oil and natural gas produce steam at the Central Steam Facility (CSF). Responding to market conditions, fuel oil and natural gas is historically used whenever each respective fuel is least expensive. However, given the price disparity between

Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs.

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2013	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Utility Energy Service Contract (UESC)*	Greenhouse Gas Reduction and Energy Conservation	15,448,400	Greenhouse Gas	0	750,000	1,380,000	UESC includes: installed energy efficient lighting and controls in 17 buildings; energy management control upgrades in 9 buildings; and installation of an energy-efficient 1,250 ton electric centrifugal chiller at the Chilled Water Facility.
Refurbished Cafeteria Food Waste Disposal Area	Recycling	200	Recyclables	N/A	4,500	N/A	New countertops and posters were incorporated into the BNL Cafeteria food waste disposal area. The countertops do not allow food trays to be thrown in the trash and the posters indicate what product goes in each disposal opening.
Once Thru Cooling	Water Conservation	7,188,480	Water	\$0	\$0	\$1,000	Replaced a once thru cooling system with a closed loop system supplied by the Chilled Water Plant.
Replacement of X-Ray Film Processing with Chemiluminescent Imaging	Substitution	835	Hazardous and Industrial Liquid Wastes	\$0	\$5,500	\$179,000	Cost savings reflect labor savings, waste disposal savings, and items (such as film) which will no longer need to be purchased.
Motion Sensors for Building 725	Energy Conservation	N/A	Greenhouse Gas and Energy Conservation	N/A	\$0	\$6,000	Installation of motion-sensored lighting in hallways, restrooms, and conference rooms in Building 725 during 2011.
LED Lighting in 490 Conference Room	Energy Conservation	N/A	Greenhouse Gas, Energy Conservation, Manpower	\$0	\$0	\$3,710	(40) 65-Watt incandescent bulbs were replaced with LED bulbs during 2011. Savings = \$1190/year in energy costs and \$2520/year in manpower costs.
Motion Sensors for Building 820	Energy Conservation	N/A	Greenhouse Gas and Energy Conservation	N/A	\$0	\$1,650	Installation of motion-sensored lighting in Physics research area of Building 820.
Sewage Sludge	Publicly Owned Treatment Works (POTW)	3,000	Low-Level Radiological Waste (LLRW)	\$0	\$12,000	-\$12,000	Radiological constituents were eliminated from within the Sewage Treatment Facility and the sludge is now sent to a POTW.
Alkaline Batteries	Recycling	174	Industrial Waste	\$10	\$0	\$10	150 pounds of alkaline batteries were collected and sent for recycling.
BioDiesel tank, E-85, CNG	Alternative Fuels	0	Greenhouse Gas and Energy Conservation	\$0	\$0	\$0	BNL is utilizing different alternative fuels to operate maintenance vehicles.
Motion Sensors for labs*	Energy Conservation	N/A	Greenhouse Gas and Energy Conservation	N/A	\$0	\$5,817	Installation of motion detector lighting in common areas of Buildings 490 and 463.

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Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs (continued).

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2013	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
"Bio Circle Cleaner" Parts Washer	Substitution	640	Hazardous Waste	\$10,000	\$0	\$10,000	Eliminates the need for toxic solvents, chemical storage, and disposal associated with the cleaning of vacuum parts.
Aerosol Can Disposal System	Recycling	528	Hazardous Waste	\$0	\$0	\$0	Empty aerosol cans are recycled as scrap, rather than sent to the Waste Management Division as hazardous waste. Eight units (F&O=5; CA=1; NSLS=1; BES=1) each handle 66 lbs. of hazardous waste.
Electronic Reuse	Reuse	20,991	E-Waste	\$0	\$0	\$0	BNL tracks electronic equipment and takes a reuse credit for transfer of equipment to another user.
Building Demolition Recycling	Recycling	11,000,000	Industrial Waste	\$484,935	\$25,000	\$459,935	On-site demolition products (steel and concrete) are segregated, recycled, and reused.
System One Parts Cleaner	Substitution	1,280	Hazardous Waste	\$12,000	\$0	\$12,000	Central Fabrications and Motor Pool each purchased a System One parts washer to re-distill dirty solvent, eliminating the need for a vendor, such as Safety Kleen. Removed grit and sludge are mixed with the waste oil.
Animal bedding Conveying System	Composting	20,000	Low-level Radiological Waste (LLRW)	\$0	\$0	\$0	Animal bedding material is no longer sent to sanitary sewer; it is now conveyed to a dumpster that is emptied and composted at the slump dump. The sanitary sludge was previously sent out as LLRW.
Lead Acid Batteries	Recycled	2,720	Universal Waste	\$0	\$0	\$0	Avoids hazardous waste disposal costs for approximately 40 lbs. of lead per battery.
Short Half-Life Waste - CA	Decay in Storage	73	Radioactive Waste	\$0	\$0	\$0	During 2014, 11 boxes of filters from Buildings 914 and 919 (77 ft3) were managed in accordance with BNL decay-in-storage requirements, rendering the wastes eligible for volumetric release.
Cooling Tower Chemicals	Source Reduction	6,000	Industrial Waste	\$12,000	\$0	\$12,000	Ozone water treatment units were installed on cooling towers at the National Space Radiation Laboratory (Building 957), the Special Ejection Magnet (Building 912A) and the Relativistic Heavy Ion Collider Research Facility (Building 1004) for biological control of cooling water. These systems eliminate the need for water treatment chemicals (typically toxic biocides), save labor, and reduce analytical costs for monitoring cooling tower blowdown.

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Table 2-2. BNL Pollution Prevention, Waste Reduction, and Recycling Programs.(concluded).

Waste Description	Type of Project	Pounds Reduced, Reused, Recycled or Conserved in 2013	Waste Type	Potential Costs for Treatment and Disposal	Cost of Recycle, Prevention	Estimated Cost Savings	Project Description Details
Blasocut Machining Coolant	Recycled/ Reused	38,800	Industrial Waste	\$4,850	\$0	\$14,450	Central Shops Division operates a recycling system that reclaims Blasocut machining coolant and supplies it Laboratory-wide. In 2014, 4,850 gallons (38,800 lbs.) of Blasocut lubricant were recycled. Recycling involves aeration, centrifuge, and filtration. This avoids the cost of disposal as industrial waste and an avoided cost of buying 12 drums of concentrate (\$800/drum) and 97 empty drums for shipping (\$50/drum).
Fluorescent Bulbs	Recycled	19,807	Universal waste	\$0	\$20,000	-\$20,000	Fluorescent bulbs are collected and sent to a recycling facility under the Universal Waste exemption rule.
Used Motor Oil	Energy Recovery	2,000	Industrial Waste	\$2,000	\$0	\$2,000	Used motor oil from the motor pool and the on-site gas station is given to Sirebel's Laundry Service to fire their boilers. In 2014, they collected 2,000 gallons of oil at no charge to BNL, which avoided the costs for disposal and 40 shipping drums (\$50/drum).
Office Paper	Recycled	300,000	Industrial Waste	\$0	\$0	\$0	Cost avoidance based on \$105/ton for disposal as trash, plus \$40/ton revenue.
Cardboard	Recycled	155,160	Industrial Waste	\$0	\$0	\$0	Cost avoidance based on \$1,055/ton for disposal as trash, plus \$25/ton revenue.
Electronic Waste	Recycled	58,500	Industrial and Universal Waste	\$0	\$0	\$0	Cost avoidance based on \$105/ton for disposal as trash, plus \$900/ton revenue.
Metals	Recycled	511,150	Industrial Waste	\$0	\$0	\$0	Cost avoidance based on \$105/ton for disposal as trash, plus \$900/ton revenue.
Bottles/Cans	Recycled	34,200	Industrial Waste	\$0	\$0	\$0	Cost avoidance based on \$105/ton for disposal as trash.
Construction Debris	Recycled	701,100	Industrial Waste	\$0	\$0	\$18,229	Cost avoidance based on \$52/ton difference for disposal as trash.
TOTALS		35,514,038		\$525,795	\$817,000	\$2,073,801	

* Cost savings of projects funded by the BNL Pollution Prevention Council will be tracked for 3 years.

natural gas and oil, BNL will continue to purchase natural gas over oil, further reducing greenhouse gas emissions (GHG). Additional information on natural gas and fuel oil use can be found in Chapter 4.

BNL continues to participate in the New York Independent System Operator (NYISO) Special Case Resource (SCR) Program, which is an electric load reduction curtailment program. Through this program, the Laboratory has agreed to reduce electrical demand during critical days throughout the summer when NYISO expects customer demand to meet or exceed the available supply. In return, BNL sometimes receives a rebate for each megawatt reduced on each curtailment day. BNL strives to keep electric loads at a minimum during the summer by scheduling operations at the Relativistic Heavy Ion Collider (RHIC) to avoid peak demand periods. In 2014, this scheduling reduced the electric demand at the Laboratory by 25 MW, saving approximately \$1.7 million in electric costs and helping to maintain the reliability of the Long Island Power Authority (LIPA) electric system to meet all of its users' needs. BNL also maintains a contract with the New York Power Authority (NYPA) that resulted in an overall cost avoidance of \$25.3 million in 2014.

The Laboratory will continue to seek alternative energy sources to meet its future energy needs, support federally required "green" initiatives, and reduce energy costs. Further, BNL's energy supply includes approximately 120 million kWh of clean, renewable energy credits (RECs) received through the Long Island Solar Farm (LISF).

In 2011, BP Solar completed construction of the LISF on DOE/BNL property. The array is currently the largest solar photovoltaic (PV) array (32 MW) in the Northeast and spans 195 acres with 164,000 panels. BNL worked extensively with LIPA, BP Solar, the State of New York, and other organizations to evaluate the site and develop the project, with LIPA purchasing the output through a 20-year Power Purchase Contract. The estimated annual output of 44 million kWh results in an avoidance of approximately 31,000 tons of carbon per year over its 30- to 40-year life span. The actual output

for the first three operational years was an average of 54 million kWh/year, substantially above the estimated annual average value. As an outcome of constructing this large array on site, the Laboratory has developed a solar research program that looks at impacts of climate change on large utility-scale PV systems, as well for research and development for solar power storage and inverter efficiencies. The Federal Energy Management Program (FEMP) recognizes the importance of the efforts of BNL and the DOE Brookhaven Site Office to host the LISF, and provides credit toward BNL's SSP renewable energy goal.

In May 2014, the Laboratory completed the installation of the first phase of the 1 MW solar PV array for additional research. The 500 kW phase one array is currently generating approximately 520,000 kWh/year of electricity. The remaining 500 kW is expected to be completed in 2016-2017.

To reduce energy use and costs at non-research facilities, several additional activities were undertaken by the BNL Energy Management Group in 2014:

- *NYPA Power Contract:* Third full year of a 10-year contract that includes 15 MW of renewable (nearly zero GHG) hydropower. This contract is estimated to save in excess of \$26 million per year compared to prevailing energy rates, with an option to renew for an additional 5 years. Actual savings for FY 2014 were \$25.3 million.
- *DOE Sustainability Initiative:* The Energy Management Group continues to provide substantial support to the Federal/DOE-wide Sustainability Initiative, and has created a BNL Sustainability Leadership Team. The team has developed a formal site-wide sustainability program beyond DOE requirements, participates in one of three subcommittees for DOE on sustainability initiatives, and provides numerous evaluations and estimates on energy use, GHG, renewable energy, and energy-efficiency options.
- *Substantial Progress on Several Initiatives included in BNL's annual SSP:* New electric and steam meter installations; funding for energy conservation initiatives; new energy-

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Table 2-3. BNL Recycled Program Summary, 2000-2014.

Recycled Waste *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mixed paper	336	246	209	182	185	193	184	177	151	127	174	186	142	160	150
Cardboard	132	127	157	176	179	143	135	121	147	152	141	126	100	97	78
Bottles/Cans	19.5	29.3	19	23	22	22.1	27.7	24.4	19.6	23.7	24	22.5	18	16.5	17.1
Tires	0		3.5	12.3	11	12.8	32.5	19.9	34.5	15.5	10.1	9.2	10	7.1	7.6
Construction debris	243	289	304	334	367	350	297	287	302	312	416	256	380	304	351
Used motor oil (gallons)	3,296	3,335	1,920	3,920	3,860	4,590	2,780	2,020	1,500	1,568	1,700	1,145	1,585	1,550	2,000
Metals	534	44	48	193	128	559	158	382	460	91	131	84	278	174	256
Automotive batteries	2.2	4.8	6.3	4.6	5	4.6	5.5	2.5	2.7	4	1.6	2.1	2	2.1	1.4
Printer/Toner cartridges (units)	n/a	363	449	187	105	0	0	0	3,078	1,251	4,132	4,186	4,100	11,233	2,174
Fluorescent bulbs (units)	5,874	17,112	25,067	13,611	12,592	7,930	11,740	25,448	36,741	10,223	8,839	20,220	15,727	13,540	19,807
Blasocut coolant (gallons)	n/a	n/a	8,180	5,030	6,450	3,890	3,970	2,432	3,340	3,810	4,830	5,660	5,610	5,650	4,850
Antifreeze (gallons)	n/a	n/a	0	165	325	0	0	0	0	0	0	0	700	822	0
Tritium exit signs (each)	n/a	n/a	28	181	142	0	0	0	0	0	0	18	0	0	0
Smoke detectors (each)	n/a	n/a	40	0	0	0	0	0	0	0	0	0	0	0	0
Road base	n/a	n/a	2,016	0	2,666	0	0	0	0	0	0	0	0	0	0
Electronic reuse	n/a	n/a	0	0	0	0	0	0	16.3	11.4	12	11.6	3.2	1.4	10.5
Scrap electronics	n/a	n/a	0	0	0	6.1	70.3	40.5	48.9	17	16.7	19.9	30.9	23	29.3
Animal Bedding (composted)	n/a	n/a	0	0	0	0	6.3	19.6	42	41	52	54	3.3	30	10
Tyvek (lbs)	n/a	n/a	0	0	0	0	0	0	0	84	60	92	105	0	0
Demolition Projects															
Metals	n/a	n/a	8	23	11	6	35	0	0	0	0	0	60	90	0
Concrete	n/a	n/a	891	590	3,000	328	5,505	6175	0	0	4,050	0	4,050	3,500	4,000
Construction and debris	n/a	n/a	790	388	1,200	157	818	0	0	0	0	0	0	0	0

Notes: All units are tons, except where noted.

Figure 2-2. Annual Potable Water Use, 1999-2014.

efficient lighting installed in parking lots and offices; the purchase of Renewable Energy Credits (RECs) in meeting BNL's SSP goal; and training various parties on energy conservation initiatives.

- **Utility Energy Services Contract (UESC):** Continued support to DOE/BHSO in developing and implementing a UESC, which included a preliminary audit, completion of a follow-on Investment Grade Audit (IGA), and completion of the UESC contract terms and requirements. A contract was awarded in late October 2013 and planned work began in late December. The UESC scope currently includes energy-efficient lighting, new building controls and commissioning, and an energy-efficient chiller project. The project was approximately 50 percent completed at the end of 2014 and is expected to be completed in June 2015. The environmental benefits of this UESC include: electrical savings of 3,549,114 kWh/year; fuel savings of 89,541 mmBtu/year; greenhouse gas reduction of 7,022 MTCO₂e; and a building energy intensity reduction of 11 percent.
- **Energy Conservation:** Energy and water evaluations are completed for 25 percent of the site each year. Cost-effective projects are identified and proposed for funding, as appropriate.
- **High Performance Sustainability Buildings (HPSB):** Substantial completion of various energy and water conservation projects to achieve compliance in the EPA Portfolio Manager program. BNL is currently on target to meet or exceed the HPSB goal.
- **Renewable Energy:** Continued project support for the LISF Project and the Research and Development (R&A) solar PV array (part of NSERC), and annual purchases of Renewable Energy Credits (REC's) to meet targeted goals.
- **Central Chilled Water Facility (CCWF)-Phase II:** The CCWF Phase-II project was completed in 2011 and is now providing chilled water to BNL buildings and processes such as the National Synchrotron Light Source II (NSLS-II) and the data center, using modern energy-efficient chillers. The CCWF utilizes a 3.2 million gallon chilled water storage tank that is used to reduce peak electric demand by producing and storing chilled water during the night.
- **Natural Gas Purchase Contract:** BNL is currently saving approximately \$7.1 million per year compared to oil and \$400k compared to purchasing directly from National Grid.
- **Energy Savings:** 25 MW of demand is rescheduled each year to avoid coincid-

Figure 2-3. BNL Building Energy Performance, 2014 (Btu/SF Change Percent vs. Baseline Years).

ing with the utility summer peak, saving over \$1.7 million in electricity charges. In addition, work continues in the replacement of aging, inefficient T-40 fluorescent lighting fixtures with new, high efficiency T-8 lighting fixtures (200 to 300 fixtures are typically replaced annually), saving tens of thousands of kWhs each year and reducing costs by several thousand dollars.

Due to continued conservation efforts, overall facilities energy usage for FY 2014 was approximately 22.6 percent less than in FY 2003, saving \$2.7 million. In addition, approximately 61,000 gasoline gallon equivalents (gge) gas alternative fuels were used in place of gasoline for the Laboratory's vehicle fleet.

The National Energy Conservation Policy Act, as amended by the Federal Energy Management Improvement Act of 1988 and the Energy Policy Acts of 1992 and 2005, as well as the Energy Independence and Security Act (EISA) of 2007, requires federal agencies to apply energy

conservation measures and to improve federal building design to reduce energy consumption per square foot. Current goals are to reduce energy consumption per square foot, relative to 2003, by 2 percent per year from FY 2006-FY 2015. Further, EO 13514 and associated orders have set even more stringent requirements, including increased use of renewable energy and reductions in transportation fuels that go significantly beyond the previous goal of a 30 percent reduction by FY 2015, compared to FY 1985.

As shown in Figure 2-3, BNL's energy use per square foot in 2014 was 30 percent less than in FY 1985 and 22.6 percent less than in FY 2003. It is important to note that energy use for buildings and facilities at the Laboratory is largely weather dependent.

2.3.4.7 Natural and Cultural Resource Management Programs

Through its Natural Resource Management Plan (BNL 2011), BNL continues to enhance

its Natural Resource Management Program in cooperation with the Foundation for Ecological Research in the Northeast (FERN) and the Upton Ecological and Research Reserve. The Laboratory also continues to enhance its Cultural Resource Management Program. A BNL Cultural Resource Management Plan (BNL 2013a) was developed to identify and manage properties that are determined to be eligible or potentially eligible for inclusion on the National Register of Historic Places. See Chapter 6 for further information about these programs.

2.3.4.8 Environmental Restoration

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress in 1980. As part of CERCLA, EPA established the National Priorities List, which identifies sites where cleanup of past contamination is required. BNL was placed on the list with 27 other Long Island sites, 12 of which are in Suffolk County.

Each step of the CERCLA cleanup process is reviewed and approved by DOE, EPA, and NYSDEC, under an Interagency Agreement (IAG). This agreement was formalized in 1992. Although not a formal signatory of the IAG, the Suffolk County Department of Health Services (SCDHS) also plays a key role in the review process. Most of the contamination at the Laboratory is associated with past accidental spills and outmoded practices for handling, storing, and disposing of chemical and radiological material.

BNL follows the CERCLA process, which includes the following steps:

- Conduct a Remedial Investigation to characterize the nature and extent of contamination and assess the associated risks.
- Prepare a Feasibility Study and Proposed Plan to identify and evaluate remedial action alternatives and present the proposed alternative.
- Issue a Record of Decision (ROD), which is the remedy/corrective action agreed to by DOE, EPA, and NYSDEC.
- Perform the Remedial Design/Remedial Action, which includes final design, construction specifications, and carrying out the remedy selected.

In 2014, BNL's 12 active groundwater treatment systems removed approximately 143 pounds of volatile organic compounds (VOCs) and 1.2 mCi of strontium-90 (Sr-90) from the sole source aquifer. Following approval from the regulators, the North Street East Treatment System was shut down and placed in an operationally-ready stand-by mode in June 2014. The North Street Treatment system was placed back into operational mode due to a rebound in VOC concentrations. In addition, two new groundwater extraction wells were installed for the Industrial Park Treatment System. Also in 2014, long-term surveillance and maintenance (S&M) of the Laboratory's Brookhaven Graphite Research Reactor (BGRR) and the High Flux Beam Reactor (HFBR) continued. In accordance with the ROD, demolition of the HFBR stack will be completed prior to 2020.

Post-cleanup monitoring of Peconic River surface water, sediment, fish, and wetland vegetation continued in 2014, and the results are reported in Chapter 6 of this report. Monitoring and control of invasive species was performed at three Peconic wetland areas that were remediated in 2011. This monitoring continued through 2014, resulting in the meeting of all federal requirements.

The groundwater systems operate in accordance with the Operations and Maintenance (O&M) manuals, while the Peconic and surface soil cleanup areas are monitored via the Soil and Peconic River Surveillance and Maintenance (S&M) Plan (BNL 2013b). Institutional controls are also monitored and maintained for the cleanup areas in accordance with the RODs to help ensure the remedies remain protective of human health and the environment. An annual evaluation of these controls is submitted to the regulators.

Table 2-4 provides a description of each Operable Unit (OU), and a summary of environmental restoration actions taken. See Chapter 7 and SER Volume II, Groundwater Status Report, for further details.

2.4 IMPLEMENTING THE ENVIRONMENTAL MANAGEMENT SYSTEM

2.4.1 Structure and Responsibility

All employees at BNL have clearly defined roles and responsibilities in key areas, including

environmental protection. Employees are required to develop and sign their own Roles, Responsibilities, Accountabilities, and Authorities (R2A2) document, which must also be signed by two levels of supervision. BSA has clearly defined expectations for management and staff which must be included in this document. Under the BSA performance-based management model, senior managers must communicate their expectation that all line managers and staff take full responsibility for their actions and be held accountable for ESSH performance. Environmental and waste management technical support personnel assist the line organizations with identifying and carrying out their environmental responsibilities. The Environmental Compliance Representative Program, initiated in 1998, is an effective means of integrating environmental planning and pollution prevention into the work planning processes of the line organizations. A comprehensive training program for staff, visiting scientists, and contractor personnel is also in place, thus ensuring that all personnel are aware of their ESSH responsibilities.

2.4.2 Communication and Community Involvement

In support of BNL's EMS commitment to communication and community involvement, the External Affairs and Stakeholder Relations (EASR) Office develops best-in-class communications, science education, government relations, and community involvement programs that advance the science and science education missions of the Laboratory (BNL 2005). EASR contributes to public understanding of science and enhances the value of the Laboratory as a community asset and ensures that internal and external stakeholders are properly informed and have a voice in decisions of interest and importance to them. EASR also works to maintain relationships with BNL employees and external stakeholders that include neighbors, business leaders, elected officials, and regulators to provide an understanding of the Laboratory's science and operations, including environmental stewardship and restoration activities, and to incorporate community input into BNL's decision-making process.

To facilitate stakeholder input, EASR's

Stakeholder Relations Office participates in or conducts on- and off-site meetings which include discussions, presentations, roundtables, and workshops. Stakeholder Relations staff attend local civic association meetings, canvass surrounding neighborhoods, conduct Laboratory tours, and coordinate informal information sessions and formal public meetings, which are held during public comment periods for environmental projects. In addition, EASR manages programs to increase internal stakeholder awareness, understanding, and support of Laboratory initiatives, fosters two-way communications, and updates internal stakeholders on BNL priorities, news, programs, and events.

2.4.2.1 Communication Forums

To create opportunities for effective dialogue between the Laboratory and its stakeholders, several forums for communication and involvement have been established:

- The Brookhaven Executive Roundtable (BER), established in 1997 by DOE's Brookhaven Site Office, meets routinely to update local, state, and federal elected officials, regulators, and other government agencies on environmental and operational issues, as well as scientific discoveries and initiatives.
- The Community Advisory Council (CAC), established by BNL in 1998, advises Laboratory management primarily on environmental, health, and safety issues related to the Laboratory that are of importance to the community. The CAC is comprised of 27 member organizations and individuals representing civic, education, employee, community, environmental, business, and health interests. The CAC sets its own agenda in cooperation with BNL and meets monthly, except for July and August. The CAC is one of the primary ways the Laboratory keeps the community informed. Meetings are open to the public and are announced in the monthly community e-newsletter, *LabLink*, on the Stakeholders Relations website. An opportunity for public comment is provided at each meeting and organizations interested in participating on the CAC are encouraged

to attend meetings and make their interest known.

- Monthly teleconference calls are held with parties to the Laboratory's Interagency Agreement and other federal, state, and local regulators to keep them up-to-date on project status. The calls also provide the opportunity to gather input and feedback and to discuss emerging environmental findings and initiatives.
- The Stakeholder Relations Office website is used to host links to the CAC webpage, which contains meeting agendas and past meeting presentations and minutes. Stakeholder Relations also manages several outreach programs that provide opportunities for stakeholders to become familiar with the Laboratory's facilities and research projects. Outreach programs include:
 - *Tour Program*: Opportunities to learn about BNL are offered to college, university, professional, and community groups. Tour groups visit the Laboratory's scientific machines and research facilities and meet with scientists to discuss research. Agendas are developed to meet the interests of the groups, and may include sustainability and environmental stewardship issues. Tours were provided for more than 2,250 visitors in 2014.
 - *The Speakers' Bureau*: Speakers are provided for educational institutions and community organizations, such as Rotary Clubs, civic organizations, school assemblies, and professional societies, to update them on Laboratory research and operations accomplishments, including environmental stewardship.
 - *Summer Sundays*: Held on four Sundays each summer, these open houses enable the public to visit BNL science facilities, experience hands-on activities, and learn about research projects and environmental stewardship programs. In 2014, more than 5,000 visitors participated in the program.
 - *PubSci*: BNL's new quarterly science café and conversation series where the Laboratory's distinguished scientists appear at public venues to discuss cutting-edge

topics and research in an informal setting. During 2014, science-interested community members and BNL researchers discussed science topics that included the "Building Blocks of Matter," "Exploring the Huge Impacts of the Ultra Small," and "Illuminating the Secret Structures of the Atomic World."

- *ScienceOnScreen*: A new partnership program with the Huntington Cinema Arts Centre that gives BNL scientists an opportunity to present classic, cult, or documentary movies that serve as a "jumping-off" point to discuss their research began in 2014 with a showing of "Particle Fever," a film documenting the hunt for the Higgs boson. The program, supported by a grant from the Coolidge Corner Theatre Foundation with major support from the Alfred P. Sloan Foundation, will continue in 2015.

The Laboratory participates in various outreach events throughout the year that include festivals, workshops, BNL's Earth Day celebration, and the Suffolk County Planning Federation Conference. Brown bag lunch meetings for employees are held periodically and cover topics of interest, including project updates, newly proposed initiatives, wildlife management concerns, and employee benefits information.

BNL's Media & Communications Office issues press releases to news and media outlets, and publishes weekly employee newsletters—*Brookhaven This Week* and *The Brookhaven Digest*. In addition, the Director's Office web-based publication, the *Monday Memo*, is issued bi-weekly to employees and focuses on administrative topics important to the Laboratory population.

The Laboratory maintains an informative website at www.bnl.gov, where these publications, as well as extensive information about BNL's science and operations, past and present, are posted. In addition, employees and the community can subscribe to the Laboratory's e-mail news service at <https://lists.bnl.gov/mailman/listinfo/bnl-announce-1>. Community members who have questions or comments can "Let us know" by clicking on the link found under

CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

Table 2-4. Summary of BNL 2014 Environmental Restoration Activities.

Project	Description	Environmental Restoration Actions
Soil Projects	Operable Unit (OU) I/II/III/VII	<ul style="list-style-type: none"> Performed monitoring and maintenance of institutional controls for cleanup areas.
Groundwater Projects	OU III/V/VI	<ul style="list-style-type: none"> Continued operation of 10 groundwater treatment systems that remove volatile organic compounds (VOCs), and two systems that remove strontium-90 (Sr-90). Following approval from the regulatory agencies, the Industrial Park East treatment system was decommissioned in 2014. Following regulatory approval, the North Street East treatment system was shut down and placed in operationally-ready stand-by mode. Installed new extraction wells to address deeper VOC contamination in the Industrial Park area. 143 pounds of VOCs and 1.2 mCi of Sr-90 were removed during the treatment of 1.3 billion gallons of groundwater. Since the first groundwater treatment system started operating in December 1996, approximately 7,276 pounds of VOCs and 29.9 mCi of Sr-90 have been removed, while treating over 23 billion gallons of groundwater. Collected and analyzed approximately 1,514 sets of groundwater samples from 631 monitoring wells. Installed 67 temporary wells and collected multiple samples from each location. Continued monitoring the g-2 tritium plume using temporary and permanent monitoring wells.
Peconic River	OU V	<ul style="list-style-type: none"> Continued long-term post-cleanup monitoring of Peconic River surface water and sediment. Fish collection was performed in 2013; next collection will be in 2015. Completed monitoring and maintenance of invasive species at three excavated sediment locations within the Peconic River.
Reactors	Brookhaven Graphite Research Reactor (BGRR)	<ul style="list-style-type: none"> Continued long-term surveillance and maintenance, including the replacement of 76 windows on the second and third floor former offices.
	High Flux Beam Reactor (HFBR)	<ul style="list-style-type: none"> Continued long-term surveillance and maintenance.
	Stack (Building 705)	<ul style="list-style-type: none"> Continued long-term surveillance and maintenance.
	Brookhaven Medical Research Reactor (BMRR)	<ul style="list-style-type: none"> Continued surveillance and maintenance activities.
Buildings 810/811	Radiological Liquid Processing Facility *	<ul style="list-style-type: none"> Performed routine surveillance and maintenance of the facility. The Environmental Protection Division continued utility isolation at Building 811 in preparation for demolition and removal of contaminated soil and concrete in 2015.
Building 801	Inactive Radiological Liquid Holdup Facility	<ul style="list-style-type: none"> Performed routine surveillance and maintenance of the facility.
Building 650	Inactive Radiological Decon Facility *	<ul style="list-style-type: none"> Performed routine surveillance and maintenance of the facility.

“Listening to you” on the Stakeholder Relations Office website at www.bnl.gov/stakeholder/. Community members can also subscribe to the monthly e-newsletter, *LabLink*, found on the Stakeholder Relations webpage at www.bnl.gov/lablink. *LabLink*, which keeps the community informed about happenings at BNL, explains some of the science behind Laboratory research, and invites subscribers to educational and cultural events.

2.4.2.2 Community Involvement in Cleanup Projects

In 2014, BNL updated stakeholders on the progress of environmental cleanup projects, additional initiatives, and health and safety issues via mailings and briefings and presentations given at CAC and BER meetings. These topics included:

- **Natural Resources Program:** In January and October, the CAC received updates on the BNL’s natural resources, including: the status of the flora and fauna on site, deer management and the 4-Poster tick control system, deer and fish sampling, bat surveys, intern projects, and research at the LISF. The CAC was also provided with a preview of the 2014 sampling data from the Peconic River and the path forward was discussed with regulators.
- **Environmental Cleanup Program:** In March, the CAC received a comprehensive presentation on the significant progress made over the past 20 years toward cleanup of the BNL site. The 32 Areas of Concern under the Superfund program were reviewed, as well as a timeline for cleanup objectives and those that have been met were discussed. The costs to date, approximately \$567M, work in progress, and lessons learned were also discussed.
- **FHWMF Perimeter Soils:** In April and November, the CAC was given an update on the final phase of cleanup of soils contaminated as a result of historical operations at the Former Hazardous Waste Management Facility (FHWMF).
- **History of the BNL Site:** In April, the CAC received a historical overview of the transition of the site from a World War I Army training camp to a multi-purpose national laboratory.

- **2013 Site Environmental Report:** In September, the CAC received a presentation on the Laboratory’s environmental impact for the previous year. Updates on the BNL’s EMS and opportunities for improvement, pollution prevention projects implemented during the year, waste generation, and energy management and conservation were discussed. Air and water quality monitoring results were provided, and the radiological dose assessment was explained.
- **Wastewater Treatment Modification Projects:** In November, the CAC received an update on the transition of the Sewage Treatment Plant outfall from discharging to the Peconic River to newly constructed groundwater recharge basins, as well as effluent sampling of mercury concentrations.
- **2013 Groundwater Status Report:** The CAC received a presentation on the highlights of the annual report including the current status of treatment systems and VOC remediation. Details on the shutdown of the North Street East system and the status of the Deep VOC characterization, new extraction wells, and the Building 452 Freon-11 treatment system were provided.

Working closely with the community, employees, elected officials, and regulatory agency representatives, DOE and BNL continue to openly share information on issues, projects, and programs and welcomes all input and feedback offered from the community.

2.4.3 Monitoring and Measurement

The Laboratory monitors effluents and emissions to ensure the effectiveness of controls, adherence to regulatory requirements, and timely identification and implementation of corrective measures. BNL’s Environmental Monitoring Program is a comprehensive, sitewide program that identifies potential pathways for exposure of the public and employees, evaluates the impact activities have on the environment, and ensures compliance with environmental permit requirements. The monitoring program is reviewed and revised, as necessary or on an annual basis, to reflect changes in permit requirements, changes in facility-specific monitoring activities, or the

need to increase or decrease monitoring based on a review of previous analytical results.

As required under DOE Order 436.1, Departmental Sustainability, BNL prepares an Environmental Monitoring Plan (BNL 2014), which outlines annual sampling goals by media and frequency. The plan uses the EPA Data Quality Objective approach for documenting the decisions associated with the monitoring program. In addition to the required triennial update, an annual electronic update is also prepared.

As shown in Table 2-5, in 2014 there were 6,489 sampling events of groundwater, potable water, precipitation, air, plants and animals, soil, sediment, and discharges under the Environmental Monitoring Program. Specific sampling programs for the various media are described further in Chapters 3 through 8.

The Environmental Monitoring Program

addresses three components: compliance, restoration, and surveillance monitoring.

2.4.3.1 Compliance Monitoring

Compliance monitoring is conducted to ensure that wastewater effluents, air emissions, and groundwater quality comply with regulatory and permit limits issued under the federal Clean Air Act, Clean Water Act, Oil Pollution Act, SDWA, and the New York State equivalents. Included in compliance monitoring are the following:

- *Air emissions monitoring* is conducted at reactors (no longer in operation), accelerators, and other radiological emission sources, as well as the CSF. Real-time, continuous emission monitoring equipment is installed and maintained at some of these facilities, as required by permits and other regulations. At other facilities, samples are collected and

Table 2-5. Summary of BNL Sampling Program Sorted by Media, 2014.

Environmental Media	No. of Sampling Events(a)	Purpose
Groundwater	1,737 (b)	Groundwater is monitored to evaluate impacts from past and present operations on groundwater quality, under the Environmental Restoration, Environmental Surveillance, and Compliance sampling programs. See Chapter 7 and SER Volume II, Groundwater Status Report, for further detail.
On-Site Recharge Basins	99	Recharge basins used for wastewater and stormwater disposal are monitored in accordance with discharge permit requirements and for environmental surveillance purposes. See Chapter 5 for further detail.
Potable Water	55 ES 191 C	Potable water wells and the BNL distribution system are monitored routinely for chemical and radiological parameters to ensure compliance with Safe Drinking Water Act requirements. In addition, samples are collected under the Environmental Surveillance Program to ensure the source of the Laboratory's potable water is not impacted by contamination. See Chapters 3 and 7 for further detail.
Sewage Treatment Plant (STP)	126	The STP influent and effluent and several upstream and downstream Peconic River stations are monitored routinely for organic, inorganic, and radiological parameters to assess BNL impacts. The number of samples taken depends on flow. For example, samples are scheduled for collection at Station HQ monthly, but if there is no flow, no sample can be collected. See Chapters 3 and 5 for further detail.
Precipitation	18	Precipitation samples are collected from two locations to determine if radioactive emissions have impacted rainfall, and to monitor worldwide fallout from nuclear testing. The data are also used, along with wind speed, wind direction, temperature, and atmospheric stability to help model atmospheric transport and diffusion of radionuclides. See Chapter 4 for further detail.
Air – Tritium	228	Silica gel cartridges are used to collect atmospheric moisture for subsequent tritium analysis. These data are used to assess environmental tritium levels. See Chapter 4 for further detail.
Air – Particulate	353 ES/C 47 NYSDOH	Samples are collected to assess impacts from BNL operations and to facilitate reporting of emissions to regulatory agencies. Samples are also collected for the New York State Department of Health Services (NYSDOH) as part of their program to assess radiological air concentrations statewide. See Chapter 4 for further detail.
Fauna	67	Fish and deer are monitored to assess impacts on wildlife associated with past or current BNL operations. See Chapter 6 for further detail.

(continued on next page)

Table 2-5. Summary of BNL Sampling Program Sorted by Media, 2014. *(concluded)*.

Environmental Media	No. of Sampling Events(a)	Purpose
Flora	16	Vegetation is sampled to assess possible uptake of contaminants by plants and fauna, since the primary pathway from soil contamination to fauna is via ingestion. See Chapter 6 for further detail.
Soils	160	Soil samples are collected as part of the Natural Resource Management Program to assess faunal uptake, during Environmental Restoration investigative work, during the closure of drywells and underground tanks, and as part of preconstruction background sampling.
Miscellaneous	380	Samples are collected periodically from potable water fixtures and dispensers, manholes, spills, to assess process waters, and to assess sanitary discharges.
Groundwater Treatment Systems and Remediation Monitoring	1,269	Samples are collected from groundwater treatment systems and as long-term monitoring after remediation completion under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. The Laboratory has 14 operating groundwater treatment systems. See discussion in Chapter 7.
Vehicle Monitor Checks	44	Materials leaving the Laboratory pass through the on-site vehicle monitor that detects if radioactive materials are present. Any radioactive material discovered is properly disposed of through the Waste Management Program. The vehicle monitor is checked on a daily basis.
State Pollutant Discharge Elimination System (SPDES)	415	Samples are collected to ensure that the Laboratory complies with the requirements of the New York State Department of Environmental Conservation (NYSDEC)-issued SPDES permit. Samples are collected at the STP, recharge basins, and four process discharge sub-outfalls to the STP.
Flow Charts	612	Flowcharts are exchanged weekly as part of BNL's SPDES permit requirements to report discharge flow at the recharge basin outfalls.
Floating Petroleum Checks	106	Tests are performed on select petroleum storage facility monitoring wells to determine if floating petroleum products are present. The number of wells and frequency of testing is determined by NYSDEC licensing requirements (e.g., Major Petroleum Facility), NYSDEC spill response requirements (e.g., Motor Pool area), or other facility-specific sampling and analysis plans.
Radiological Monitor Checks	500	Daily instrumentation checks are conducted on the radiation monitors located in Buildings 569 and 592. These monitors are located 30 minutes upstream and at the STP. Monitoring at these locations allows for diversion of wastes containing radionuclides before they are discharged to the Peconic River.
Quality Assurance/Quality Control Samples (QA/QC)	66	To ensure that the concentrations of contaminants reported in the Site Environmental Report are accurate, additional samples are collected. These samples detect if contaminants are introduced during sampling, transportation, or analysis of the samples. QA/QC samples are also sent to the contract analytical laboratories to ensure their processes give valid, reproducible results.
Total number of sampling events	6,489	The total number of sampling events includes all samples identified in the Environmental Monitoring Plan (BNL 2014), as well as samples collected to monitor Environmental Restoration (CERCLA) projects, air and water treatment system processes, and by the Environmental Protection Division Field Sampling Team as special requests. The number does not include samples taken by Waste Management personnel, waste generators, or Environmental Compliance Representatives for waste characterization purposes.

Notes:

(a) A sampling event is the collection of samples from a single georeferenced location. Multiple samples for different analyses (i.e., tritium, gross alpha, gross beta, and volatile organic compounds) can be collected during a single sample event.

(b) Also includes sampling events from temporary wells.

C = Compliance

ES = Environmental Surveillance

analyzed periodically to ensure compliance with regulatory requirements. Analytical data are routinely reported to the permitting authority. See Chapters 3 and 4 for details.

- *Wastewater monitoring* is performed at the point of discharge to ensure that the effluent complies with release limits in the Laboratory's SPDES permits. Twenty-four point-source discharges are monitored: 12 under BNL's SPDES Permit, and 12 under equivalency permits issued to the Environmental Restoration Program for groundwater treatment systems. As required by permit conditions, samples are collected daily, weekly, monthly, or quarterly and monitored for organic, inorganic, and radiological parameters. Monthly discharge monitoring reports (DMRs) that provide analytical results and an assessment of compliance for that reporting period are filed with NYSDEC. See Chapter 3, Section 3.6 for details.
- *Groundwater monitoring* is performed to comply with regulatory operating permits. Specifically, monitoring of groundwater is required under the Major Petroleum Facility License for the CSF and the RCRA permit for the Waste Management Facility. Extensive groundwater monitoring is also conducted under the CERCLA program (described in Section 2.4.3.2 below). Additionally, to ensure that the Laboratory maintains a safe drinking water supply, BNL's potable water supply is monitored as required by SDWA, which is administered by SCDHS.

2.4.3.2 Restoration Monitoring

The Environmental Restoration Program operates and maintains groundwater treatment systems to remediate contaminant plumes both on and off site. BNL maintains an extensive network of groundwater monitoring wells to verify the effectiveness of the remediation effort. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. Additionally, surface water, sediment and fish sampling is conducted to verify the effectiveness of the Peconic River cleanup efforts. Peconic River monitoring is coordinated

with the Surveillance Monitoring Program to ensure completeness and to avoid any duplication of effort.

Details on the Peconic River monitoring program are provided in Chapter 6, and details on groundwater monitoring and restoration program are provided in Chapter 7 and SER Volume II, Groundwater Status Report.

2.4.3.3 Surveillance Monitoring

Pursuant to DOE Order 436.1, Departmental Sustainability, surveillance monitoring is performed in addition to compliance monitoring, to assess potential environmental impacts that could result from routine facility operations. The BNL Surveillance Monitoring Program involves collecting samples of ambient air, surface water, groundwater, flora, fauna, and precipitation. Samples are analyzed for organic, inorganic, and radiological contaminants. Additionally, data collected using thermoluminescent dosimeters (devices to measure radiation exposure) strategically positioned on and off site are routinely reviewed under this program. Control samples (also called background or reference samples) are collected on and off the site to compare Laboratory results to areas that could not have been affected by BNL operations.

The monitoring programs can be broken down further by the relevant law or requirement (e.g., Clean Air Act) and even further by specific environmental media and type of analysis. The results of monitoring and the analysis of the monitoring data are the subject of the remaining chapters of this report. Chapter 3 summarizes environmental requirements and compliance data, Chapters 4 through 8 give details on media-specific monitoring data and analysis, and Chapter 9 provides supporting information for understanding and validating the data shown in this report.

2.4.4 EMS Assessments

To periodically verify that the Laboratory's EMS is operating as intended, audits are conducted as part of BNL's Self-Assessment Program. The audits are designed to ensure that any nonconformance to the ISO 14001 Standard is identified and addressed. In addition, compliance with regulatory requirements is verified through

routine inspections, operational evaluations, and focused compliance audits. BNL's Self-Assessment Program consists of several processes:

- *Self-assessment* is the systematic evaluation of internal processes and performance. The approach for the environmental self-assessment program includes evaluating programs and processes within organizations that have environmental aspects. Conformance to the Laboratory's EMS requirements is verified, progress toward achieving environmental objectives is monitored, operations are inspected to verify compliance with regulatory requirements, and the overall effectiveness of the EMS is evaluated. BNL environmental staff routinely participate in these assessments. Laboratory management conducts assessments to evaluate BNL environmental performance from a programmatic perspective, to determine if there are Laboratory-wide issues that require attention, and to facilitate the identification and communication of "best management" practices used in one part of the Laboratory that could improve performance in other parts. BNL management also routinely evaluates progress on key environmental improvement projects. The Laboratory and DOE periodically perform assessments to facilitate the efficiency of assessment activities and ensure that the approach to performing the assessments meets DOE expectations.
- *Independent assessments* are performed by BNL staff members who do not have line responsibility for the work processes involved, to ensure that operations are in compliance with Laboratory requirements. These assessments verify the effectiveness and adequacy of management processes (including self-assessment programs) at the division, department, directorate, and Laboratory levels. Special investigations are also conducted to identify the root causes of problems, as well as identify corrective actions and lessons learned.

The Laboratory's Self-Assessment Program is augmented by programmatic, external audits conducted by DOE. BNL staff and subcontractors also perform periodic independent reviews.

An independent third party conducts ISO 14001 registration audits of BNL's EMS. The Laboratory is also subject to extensive oversight by external regulatory agencies (see Chapter 3 for details). Results of all assessment activities related to environmental performance are included, as appropriate, throughout this report.

2.5 ENVIRONMENTAL STEWARDSHIP AT BNL

BNL has extensive knowledge of its potential environmental vulnerabilities and current operations due to ongoing process evaluations, the work planning and control system, and the management systems for groundwater protection, environmental restoration, and information management. Compliance assurance programs have improved the Laboratory's compliance status and pollution prevention projects have reduced costs, minimized waste generation, and reused and recycled significant quantities of materials.

BNL is openly communicating with neighbors, regulators, employees, and other interested parties on environmental issues and progress. To maintain stakeholder trust, the Laboratory will continue to deliver on commitments and demonstrate improvements in environmental performance. The Site Environmental Report is an important communication mechanism, as it summarizes BNL's environmental programs and performance each year. Additional information about the Laboratory's environmental programs is available on BNL's website at <http://www.bnl.gov>.

Due to external recognition of the Laboratory's knowledge and unique experience implementing the EMS program, BNL is often asked to share its experiences, lessons learned, and successes. The Laboratory's environmental programs and projects have been recognized with international, national, and regional awards and audits have consistently observed a high level of management involvement, commitment, and support for environmental protection and the EMS. For more than 60 years, the unique, leading-edge research facilities and scientific staff at BNL have made many innovative scientific contributions possible. Today, BNL continues its research mission while focusing on cleaning up and protecting the environment.

CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

REFERENCES AND BIBLIOGRAPHY

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Compliance Status

Brookhaven National Laboratory is subject to more than 100 sets of federal, state, and local environmental regulations; numerous site-specific permits; 12 equivalency permits for operation of groundwater remediation systems; and several other binding agreements. In 2014, the Laboratory operated in compliance with most of the requirements defined in these governing documents. Instances of noncompliance were reported to regulatory agencies and corrected expeditiously.

With the exception of one nitrogen oxide emission exceedance of the new Reasonably Available Control Technology limit for Boiler 6 in July 2014, emissions of nitrogen oxides, carbon monoxide, and sulfur dioxide from the Central Steam Facility were all within permit limits. In 2014, there was one excess opacity measurement recorded by Boiler 6 during scheduled service work on the continuous opacity system and five excess opacity measurements recorded by Boiler 7. Two of the Boiler 7 excess opacity readings were due to unknown causes during boiler startup and two were the result of a blower motor failure. The final opacity excess reading occurred during startup of Boiler 7 after the blower motor was replaced; other opacity excursions reported for Boiler 6 and 7 were only noted during testing periods. In 2014, there were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fire induced activation of fixed fire suppression systems. Halon portable fire extinguishers continue to be removed and replaced by dry-chemical or clean agent units as part of an ongoing program to phase out the use of chlorofluorocarbons as extinguishing agents.

Monitoring of BNL's potable water system indicated that all drinking water requirements were met during 2014. Most of the liquid effluents discharged to surface water and groundwater also met applicable New York State Pollutant Discharge Elimination System permit requirements. Eight excursions above permit limits were reported for the year; four occurred at the Sewage Treatment Plant (two total nitrogen and two mercury), two at recharge basin 002 (oil and grease and HEDP), one at recharge basin 010 (pH), and one at recharge basin 006B (oil and grease). The permit excursions were reported to the New York State Department of Environmental Conservation (NYSDEC) and the Suffolk County Department of Health Services and corrective measures were taken. Groundwater monitoring at the Laboratory's Major Petroleum Facility continued to demonstrate that current oil storage and transfer operations are not affecting groundwater quality.

Efforts to minimize impacts of spills of materials continued in 2014. There were 28 spills in 2014, a 34 percent reduction compared to 2013. Eleven of the 28 spills met regulatory agency reporting criteria. The severity of releases were minor; and all releases were cleaned up to the satisfaction of NYSDEC.

BNL participated in 10 environmental inspections or reviews by external regulatory agencies in 2014. These inspections included Sewage Treatment Plant operations, waste water discharges to other regulated outfalls and recharge basins, hazardous waste management facilities, regulated petroleum and chemical bulk storage facilities, and the potable water system. Immediate corrective actions were taken to address all issues raised during these inspections.

CHAPTER 3: COMPLIANCE STATUS

3.1 COMPLIANCE WITH REQUIREMENTS

The federal, state, and local environmental statutes and regulations that BNL operates under are summarized in Table 3-1, along with a discussion of the Laboratory's compliance status with each. A list of all applicable environmental regulations is contained in Appendix D.

3.2 ENVIRONMENTAL PERMITS

3.2.1 Existing Permits

Many processes and facilities at BNL operate under permits issued by environmental regulatory agencies. Table 3-2 provides a complete

list of the existing permits, some of which are briefly described below.

- State Pollutant Discharge Elimination System (SPDES) permits, issued by NYSDEC.
- Major Petroleum Facility (MPF) license, issued by NYSDEC.
- Resource Conservation and Recovery Act (RCRA) permit, issued by NYSDEC for BNL's Waste Management Facility.
- Registration certificate from NYSDEC for tanks storing bulk quantities of hazardous substances (e.g., fuel oil).
- Eight radiological emission authorizations

Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL.

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	The Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) of inactive hazardous waste disposal sites. Regulators include EPA, DOE, and the New York State Department of Environmental Conservation (NYSDEC).	In 1992, BNL was the subject of a tri-party agreement with EPA, NYSDEC, and DOE. BNL site remediation is conducted by the Environmental Protection Division in accordance with milestones established under this agreement. The cleanup is currently in the long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors; this includes monitoring of institutional controls. The High Flux Beam Reactor (HFBR) stack and reactor vessel are scheduled for D&D by 2020 and 2065, respectively.	2.3.4.8
Council for Env. Quality: 40 CFR 1500–1508 DOE: 10 CFR 1021	The National Environmental Policy Act (NEPA) requires federal agencies to follow a prescribed process to anticipate the impacts on the environment of proposed major federal actions and alternatives. DOE codified its implementation of NEPA in 10 CFR 1021.	BNL is in full compliance with NEPA requirements. The Laboratory has established sitewide procedures for implementing NEPA requirements.	3.3
Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 16 USC 470	The National Historic Preservation Act (NHPA) identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places, commonly known as the National Register. Such properties can be archeological sites or historic structures, documents, records, or objects. NHPA is administered by state historic preservation offices (SHPOs; in New York State, NYSHPO).	The HFBR, BGRR complex, and World War I trenches are eligible for inclusion in the National Register. The former Cosmotron building was identified as potentially eligible in an April 1991 letter from NYSHPO. Any proposed activities involving these facilities must be identified through the NEPA/NHPA processes and evaluated to determine if the action would affect the features that make the facility eligible. Actions required for D&D of the BGRR were determined to affect its eligibility, and mitigative actions have been completed based on a Memorandum of Agreement between DOE and NYSHPO. BNL has a Cultural Resource Management Plan to ensure compliance with cultural resource regulations.	3.4
EPA: 40 CFR 50 40 CFR 60-61 40 CFR 63 40 CFR 80 40 CFR 82 40 CFR 98 NYSDEC: 6 NYCRR 200–257 6 NYCRR 307	The Clean Air Act (CAA) and the NY State Environmental Conservation Laws regulate the release of air pollutants through permits and air quality limits. Emissions of radionuclides are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations.	All air emission sources are incorporated into the BNL Title V permit or have been exempted under the New York State air program, which is codified under the New York Codes, Rules, and Regulations (NYCRR). All applicable CAA and NYCRR regulations are incorporated into the BNL Title V permit. Radiological air emission sources are registered with the EPA.	3.5

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL (continued).

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403 NYSDEC: 6 NYCRR 700–703 6 NYCRR 750	The Clean Water Act (CWA) and NY State Environmental Conservation Laws seek to improve surface water quality by establishing standards and a system of permits. Wastewater discharges are regulated by NYSDEC permits through the State Pollutant Discharge Elimination System (SPDES).	At BNL, permitted discharges include treated sanitary waste, and cooling tower and stormwater discharges. With the exception of eight excursions, these discharges met the SPDES permit limits in 2014.	3.6
EPA: 40 CFR 141–149 NYSDOH: 10 NYCRR 5	The Safe Drinking Water Act (SDWA) and New York State Department of Health (NYSDOH) standards for public water supplies establish minimum drinking water standards and monitoring requirements. SDWA requirements are enforced by the Suffolk County Department of Health Services (SCDHS).	BNL maintains a sitewide public water supply. This water supply met all primary drinking water standards in 2014. Corrective actions for all identified operation and maintenance deficiencies were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.	3.7
EPA: 40 CFR 112 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370 40 CFR 372	The Oil Pollution Act, the Emergency Planning and Community Right-to-Know Act (EPCRA), and the Superfund Amendment Reauthorization Act (SARA) require facilities with large quantities of petroleum products or chemicals to prepare emergency plans and report their inventories to EPA, the state, and local emergency planning groups.	Since some facilities at BNL store or use chemicals or petroleum in quantities exceeding threshold planning quantities, the Laboratory is subject to these requirements. BNL fully complied with all reporting and emergency planning requirements in 2014.	3.8.1 3.8.2 3.8.3
EPA: 40 CFR 260–280 NYSDEC: 6 NYCRR 360–372	The Resource Conservation Recovery Act (RCRA) and New York State Solid Waste Disposal Act govern the generation, storage, handling, and disposal of hazardous wastes.	BNL is defined as a large-quantity generator of hazardous waste and has a permitted waste management facility.	3.9
EPA: 40 CFR 700–763	The Toxic Substances Control Act (TSCA) regulates the manufacture, use, and distribution of all chemicals.	BNL manages all TSCA-regulated materials, including PCBs, and is in compliance with all requirements.	3.10
EPA: 40 CFR 162–171 ⁽⁹⁾ NYSDEC: 6 NYCRR 320 6 NYCRR 325–329	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and corresponding NY State regulations govern the manufacture, use, storage, and disposal of pesticides, herbicides, biocides, rodenticides, fungicides, tickicides, as well as the pesticide containers and residuals.	BNL contracts and/or employs NYSDEC-certified pesticide applicators for specific pesticide categories to apply pesticides, herbicides, biocides, rodenticides, fungicides, and tickicides. Each applicator attends Continuing Education training, as needed, to maintain current category certifications and BNL (or the contractor that applies regulated materials) files an annual report to the NYSDEC Pesticide Bureau detailing the above applications including EPA Registration Nos., dates of applications, method of application, target organisms, types, locations, quantity, and dosage rates of pesticides applied.	3.11
DOE: 10 CFR 1022 NYSDEC: 6 NYCRR 663 6 NYCRR 666	DOE regulations require its facilities to comply with floodplain/wetland review requirements. The New York State Fresh Water Wetlands and Wild, Scenic, and Recreational Rivers rules govern development in the state's natural waterways. Development or projects within a half-mile of regulated waters must have NYSDEC permits.	BNL is in the Peconic River watershed and has several jurisdictional wetlands; consequently, development of locations in the north and east of the site requires NYSDEC permits and review for compliance under DOE wetland/floodplain regulations. In 2014, there were three projects permitted under the New York State Fresh Water Program.	3.12
U.S. Fish & Wildlife Service: 50 CFR 17 NYSDEC: 6 NYCRR 182	The Endangered Species Act and corresponding New York State regulations prohibit activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat.	BNL is host to numerous species of flora and fauna. Many species have been categorized by New York State as endangered, threatened, or of special concern. The Laboratory's Natural Resource Management Plan outlines activities to protect these vulnerable species and their habitats (see Chapter 6).	3.13

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CHAPTER 3: COMPLIANCE STATUS

Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL (continued).

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
U.S. Fish & Wildlife Service: Migratory Bird Treaty Act 16 USC 703-712 The Bald and Golden Eagle Protection Act 16 USC 668 a-d	The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing, or possessing migratory birds is unlawful. Birds protected under the act include all common songbirds, waterfowl, shorebirds, hawks, owls, eagles, ravens, crows, native doves and pigeons, swifts, martins, swallows, and others, and includes their body parts (feathers, plumes etc), nests, and eggs. The Bald and Golden Eagle Protection Act (BGEPA) prohibits any form of possession or taking of both bald and golden eagles.	Compliance with the MBTA and the BGEPA are documented through the BNL Natural Resource Management Plan. The plan includes provisions for enhancing local habitat through the control of invasive species, planting of native grasses as food sources, and construction of nesting sites. All construction activities, including demolition, are reviewed to ensure there are no impacts to nesting birds.	3.13
DOE: Order 231.1B Manual 231.1-1A	The Environment, Safety, and Health Reporting program objective is to ensure timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department. Included in the order are the requirements for the Occurrence Reporting and Processing of Operations Program (ORPS).	BNL prepares an annual Site Environmental Report and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Health and Safety Administration (OSHA) reports. The Laboratory developed the ORPS Subject Area for staff and management who perform specific duties related to discovery, response, notification, investigation, and reporting of occurrences to BNL and DOE management. The ORPS Subject Area is supported by: Occurrence Reporting Program Description, Critiques Subject Area, Occurrence Categorizer's Procedure, and the ORPS Office Procedure.	All chapters
DOE: Order 414.1D 10 CFR 830, Subpart A Policy 450.5	The Quality Assurance (QA) program objective is to establish an effective management system using the performance requirements of this Order/Rule, coupled with consensus standards, where appropriate, to ensure: 1) products and services meet or exceed customers' expectations; 2) management support for planning, organization, resources, direction, and control ; 3) performance and quality improvement thorough rigorous assessment and corrective action and; and 4) environmental, safety, and health risks and impacts associated with work processes are minimized while maximizing reliability and performance of work products.	BNL has a Quality Assurance (QA) Program in place to implement quality management methodology throughout its management systems and associated processes to: (1) achieve and maintain compliance with applicable environmental, safety, security, and health (ESSH) requirements; (2) continue improvement in ESSH performance; (3) provide a safe and healthy workplace; (4) protect the environment and conserve resources; (5) prevent pollution; (6) provide services and products of the highest quality consistent with the needs, expectations, and resources of our customers; and (7) continuously improve processes, systems, and capabilities to improve operations and increase the value of research products delivered to customers. Having a comprehensive program ensures that all environmental monitoring data meet QA and quality control requirements. Samples are collected and analyzed using standard operating procedures, to ensure representative samples and reliable, defensible data. Quality control in the analytical labs is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated according to project-specific quality objectives before they are used to support decision making.	Chapter 9
DOE: Order 435.1 Chg. 1	The Radioactive Waste Management Program objective is to ensure that all DOE radioactive waste is managed in a manner that protects workers, public health and safety, and the environment. Order 435.1 requires all DOE organizations that generate radioactive waste to implement a waste certification program. DOE Laboratories must develop a Radioactive Waste Management Basis (RWMB) Program description, which includes exemption and timeframe requirements for staging and storing both routine and non-routine radioactive wastes.	The BNL Waste Certification Program Plan (WCPP) in the RWMB Program description defines the radioactive waste management program's structure, logic, and methodology for waste certification. New or modified operations or activities that do not fall within the scope of the RWMB Program description must be documented and approved before implementation. The Laboratory's RWMB Program description describes the BNL policies, procedures, plans, and controls demonstrating that the Laboratory has the management systems, administrative controls, and physical controls to comply with DOE Order 435.1 Chg. 1.	2.3.4.3

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Table 3-1. Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL (*concluded*).

Regulator: Codified Regulation	Regulatory Program Description	Compliance Status	Report Sections
DOE: Order 436.1	The DOE Departmental Sustainability Order replaces former DOE Orders 450.1A, Environmental Protection Programs, and 430.2B, Departmental Energy, Renewable Energy and Transportation Management. The intent of the new order is to incorporate and implement the requirements of Executive Order (EO) 13514 and to continue compliance with EO 13423. The new order is supported by DOE requirements for sound sustainability programs implemented under the DOE 2010 Strategic Sustainability Performance Plan (SSPP). Contractor requirements under the order require preparation of a Site Sustainability Plan and implementation of a sound Environmental Management System (EMS).	In accordance with the requirements of the DOE Strategic Sustainability Performance Plan, BNL has developed and implemented a Site Sustainability Plan. The Goals and Strategic Objectives of the DOE SSPP are tracked and reported on annually. BNL's EMS, as a whole, was officially registered to the ISO 14001:1996 standard in 2001 and recertified to the revised standard in 2004, 2007, 2010, and 2013. In June 2014, an external surveillance audit was conducted that found the Laboratory's EMS to be fully integrated and effective, with no minor nonconformities and many system strengths.	Chapter 2
DOE: Order 458.1, Change 3	In February 2011, DOE released DOE Order 458.1 Radiation Protection of the Public and Environment, which replaced former Order 5400.5. The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires the preparation of an Environmental Radiation Protection Plan which outlines the means by which facilities monitor their impacts on the public and environment. Full compliance with the Order was required by August 2012.	In accordance with the requirements of DOE Order 458.1, BNL maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions do not present a risk to the public, workers, or environment. These plans and programs have existed for decades and were previously implemented under prior DOE Order 5400.5 and in accordance with the current DOE O 435.1, <i>Radioactive Waste Management</i> , and 10 CFR 835. Environmental monitoring plans are well documented and the results are published annually in BNL's Site Environmental Report, which is prepared in accordance with DOE O 231.1B. The Environmental Radiation Protection Program (ERPP), which was published in September 2012, provides a record of the requirements of DOE O 458.1 and documents how the Laboratory meets these requirements.	Chapters 3, 4, 5, 6, and 8

Notes:

CFR = Code of Federal Regulations

NYCRR = New York Codes, Rules, and Regulations

SCSC = Suffolk County Sanitary Code

issued by the United States Environmental Protection Agency (EPA) under the National Emission Standards for Hazardous Air Pollutants (NESHAPs).

- Air emissions permit, issued by NYSDEC under Title V of the Clean Air Act (CAA) Amendments authorizing the operation of 13 emission units.
- Four permits issued by NYSDEC for construction activities within the Peconic River corridor.
- EPA Underground Injection Control (UIC) Area permit for the operation of 128 UIC wells (e.g., dry wells and cesspools).
- Permit for the operation of six domestic water supply wells, issued by NYSDEC.
- Twelve equivalency permits for the opera-

tion of groundwater remediation systems installed via the Interagency Agreement (Federal Facility Agreement under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]).

3.2.2 New or Modified Permits

3.2.2.1 SPDES Permits

In September 2014, BNL received approval on its SPDES Permit Renewal application, which constitutes authorization to discharge wastewater in accordance with all terms, conditions, and limitations for 12 outfalls specified in the permit.

3.2.2.2 New York State Wetlands and Wild Scenic, Recreational Rivers Act

Three actions continued in 2014 that required

CHAPTER 3: COMPLIANCE STATUS

Table 3-2. BNL Environmental Permits.

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
EPA - NESHAPs	510	Calorimeter Enclosure	BNL-689-01	None	NA	NA
EPA - NESHAPs	705	Tritium Evaporator	BNL-288-01	None	NA	NA
EPA - NESHAPs	820	Accelerator Test Facility	BNL-589-01	None	NA	NA
EPA - NESHAPs	AGS	AGS Booster - Accelerator	BNL-188-01	None	NA	NA
EPA - NESHAPs	RHIC	Accelerator	BNL-389-01	None	NA	NA
EPA - NESHAPs	931	Brookhaven LINAC Isotope Producer	BNL-2009-1	None	NA	NA
NYSDEC - NESHAPs	REF	Radiation Effects/Neutral Beam	BNL-789-01	None	NA	NA
NYSDEC - NESHAPs	RTF	Radiation Therapy Facility	BNL-489-01	None	NA	NA
EPA - SDWA	BNL	Underground Injection Control	NYU500001	(a)	NA	NA
NYSDEC - Air Equivalency	517/518	South Boundary/Middle Road System	1-51-009	NA	NA	NA
NYSDEC - Air Equivalency	598	OU I Remediation System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	539	Western South Boundary System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	TR 867	T-96 Remediation System	1-52-009	NA	NA	NA
NYSDEC - Air Equivalency	644	Freon-11 Treatment System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	517/518	South Boundary/Middle Road System	1-51-009	NA	NA	NA
NYSDEC - SPDES Equivalency	539	West South Boundary System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	598	OU I Remediation System	1-52-009	NA	NA	NA
NYSDEC - SPDES Equivalency	598	Tritium Remediation System	1-52-009	04-May-16	NA	NA
NYSDEC - SPDES Equivalency	670	Sr-90 Treatment System	None	25-Feb-18	NA	NA
NYSDEC - SPDES Equivalency	TR 829	Carbon Tetrachloride System	None	Closed out 2010	NA	NA
NYSDEC - SPDES Equivalency	OS-4	Airport/LIPA Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-2	Industrial Park East Treatment System	None	Closed out 2013	NA	NA
NYSDEC - SPDES Equivalency	OS-5	North St./North St. East Treatment System	None	NA	NA	NA
NYSDEC - SPDES Equivalency	OS-6	Ethylene Di-Bromide Treatment System	None	16-Dec-19	NA	NA
NYSDEC - SPDES Equivalency	855	Sr-90 Treatment System - BGRR/WCF	None	16-Dec-19	NA	NA
NYSDEC - SPDES Equivalency	TR 867	T-96 Remediation System	1-52-009	20-Mar-17	NA	NA
NYSDEC - SPDES Equivalency	644	Freon-11 Treatment System	1-52-009	20-Mar-17	NA	NA
NYSDEC - SPDES Equivalency	OS-2	Industrial Park Treatment System	1-52-009	30-Sep-19	NA	NA
NYSDEC - Hazardous Substance	BNL	Bulk Storage Registration Certificate	1-000263	27-Jul-15	NA	NA
NYSDEC - LI Well Permit	BNL	Domestic Potable/Process Wells	1-4722-00032/00113	13-Sep-18	NA	NA
NYSDEC - Air Quality	423	Metal Parts Cleaning Tank	1-4722-00032/00115	03-Feb-19	U-METAL	42308
NYSDEC - Air Quality	423	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	03-Feb-19	U-FUELS	42309-10
NYSDEC - Air Quality	423/630	Motor Vehicle A/C Servicing	1-4722-00032/00115	03-Feb-19	U-MVACS	MVAC1- 3
NYSDEC - Air Quality	244	Paint Spray Booth	1-4722-00032/00115	03-Feb-19	U-PAINT	24402
NYSDEC - Air Quality	244	Flammable Liquid Storage Cabinet	1-4722-00032/00115	03-Feb-19	U-PAINT	244AE
NYSDEC - Air Quality	479	Metal Parts Cleaning Tank	1-4722-00032/00115	03-Feb-19	U-METAL	47908
NYSDEC - Air Quality	510	Spin Coating Operation	1-4722-00032/00115	03-Feb-19	U-INSIG	510AK
NYSDEC - Air Quality	801	Target Processing Laboratory	1-4722-00032/00115	03-Feb-19	U-INSIG	80101
NYSDEC - Air Quality	Site	Aerosol Can Processing Units	1-4722-00032/00115	03-Feb-19	U-INSIG	AEROS
NYSDEC - Air Quality	498	Aqueous Cleaning Facility	1-4722-00032/00115	03-Feb-19	U-METAL	49801
NYSDEC - Air Quality	535B	Plating Tanks	1-4722-00032/00115	03-Feb-19	U-INSIG	53501
NYSDEC - Air Quality	535B	Etching Machine	1-4722-00032/00115	03-Feb-19	U-INSIG	53502
NYSDEC - Air Quality	535B	Printed Circuit Board Process	1-4722-00032/00115	03-Feb-19	U-INSIG	53503

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Table 3-2. BNL Environmental Permits (concluded).

Issuing Agency	Bldg. or Facility	Process/Permit Description	Permit ID No.	Expiration or Completion	Emission Unit ID	Source ID
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61005	61005
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61006	61006
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61007	61007
NYSDEC - Air Quality	610	Metal Parts Cleaning Tray	1-4722-00032/00115	03-Feb-19	U-METAL	61008
NYSDEC - Air Quality	610	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-61005	6101A
NYSDEC - Air Quality	630	Gasoline Storage and Fuel Pumps	1-4722-00032/00115	03-Feb-19	U-FUELS	63001-03
NYSDEC - Air Quality	902	Epoxy Coating/Curing Exhaust	1-4722-00032/00115	03-Feb-19	U-COILS	90206
NYSDEC - Air Quality	903	Metal Parts Cleaning Tank	1-4722-00032/00115	03-Feb-19	U-METAL	90304
NYSDEC - Air Quality	922	Electroplating Operation	1-4722-00032/00115	03-Feb-19	U-INSIG	92204
NYSDEC - Air Quality	923	Electronic Equipment Cleaning	1-4722-00032/00115	03-Feb-19	U-METAL	9231A
NYSDEC - Air Quality	923	Parts Drying Oven	1-4722-00032/00115	03-Feb-19	U-METAL	9231B
NYSDEC - Air Quality	Site	Halon 1211 Portable Extinguishers	1-4722-00032/00115	03-Feb-19	U-HALON	H1211
NYSDEC - Air Quality	Site	Halon 1301 Fire Suppression Systems	1-4722-00032/00115	03-Feb-19	U-HALON	H1301
NYSDEC - Air Quality	Site	Commercial Refrigeration Equipment	1-4722-00032/00115	03-Feb-19	U-RFRIG	COMRE
NYSDEC - Air Quality	Site	Packaged A/C Units	1-4722-00032/00115	03-Feb-19	U-RFRIG	PKG01-02
NYSDEC - Air Quality	Site	Reciprocating Chillers (46)	1-4722-00032/00115	03-Feb-19	U-RFRIG	REC01-53
NYSDEC - Air Quality	Site	Rotary Screw Chillers (15)	1-4722-00032/00115	03-Feb-19	U-RFRIG	ROTO1-15
NYSDEC - Air Quality	Site	Split A/C Units	1-4722-00032/00115	03-Feb-19	U-RFRIG	SPL01-02
NYSDEC - Air Quality	Site	Centrifugal Chillers (20)	1-4722-00032/00115	03-Feb-19	U-RFRIG	CEN01-26
NYSDEC - Air Quality	463	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	46301
NYSDEC - Air Quality	490	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	49006
NYSDEC - Air Quality	555	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	55503
NYSDEC - Air Quality	635	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	63501
NYSDEC - Air Quality	734	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	73401
NYSDEC - Air Quality	735	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	73501
NYSDEC - Air Quality	740	Diesel Emergency Generators (2)	1-4722-00032/00115	03-Feb-19	U-GENER	74001-02
NYSDEC - Air Quality	801	Diesel Emergency Generator	1-4722-00032/00115	03-Feb-19	U-GENER	80102
NYSDEC - Air Quality	912	Diesel Emergency Generators (3)	1-4722-00032/00115	03-Feb-19	U-GENER	912A1-A3
NYSDEC - Air Quality	30	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	030AB
NYSDEC - Air Quality	244	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	244AB
NYSDEC - Air Quality	422	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	422AF
NYSDEC - Air Quality	423	Combustion Unit	1-4722-00032/00115	03-Feb-19	U-SMBLR	42304
NYSDEC - Hazardous Waste	WMF	Waste Management	1-4722-00032/00102	19-Nov-16	NA	NA
NYSDEC - Water Quality	CSF	Major Petroleum Facility	1-1700	31-Mar-17	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	NY-0005835	29-Feb-20	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	1-4722-00032/00148	26-Aug-15	NA	NA
NYSDEC - Water Quality	STP	STP and Recharge Basins	1-4722-00032/00149	27-Aug-15	NA	NA
NYSDEC - Water Quality	Site	Solar farm construction	1-4722-05846/00001	06-May-15	NA	NA
NYSDEC - Water Quality	Site	Construction of Fences and Platforms at RHIC	1-4722-00032/00144	11-Jul-16	NA	NA

Notes:

(a) Permit renewal under review by EPA

A/C = Air Conditioning

AGS = Alternating Gradient Synchrotron

BGRR = Brookhaven Graphite Research Reactor

CSF = Central Steam Facility

EPA = Environmental Protection Agency

LIPA = Long Island Power Authority

NA = Not Applicable

NESHAPs = National Emission Standards for Hazardous Air Pollutants

NYSDEC = New York State Department of Environmental Conservation

OU = Operable Unit

RTF = Radiation Therapy Facility

RHIC = Relativistic Heavy Ion Collider

SDWA = Safe Drinking Water Act

SPDES = State Pollutant Discharge Elimination System

Sr-90 = Strontium-90

STP = Sewage Treatment Plant

WCF = Waste Concentration Facility

WMF = Waste Management Facility

permits under the New York State Wetland and/or Wild, Scenic and Recreational Rivers Act legislation. Continuation projects included post-construction activities associated with the on-site Long Island Solar Farm (LISF), installation of fencing and air conditioning platforms at the Relativistic Heavy Ion Collider (RHIC), and a project for the construction of recharge basins associated with upgrades to the Laboratory's Sewage Treatment Plant (STP), which will allow for the discharge of tertiary-treated wastewater directly to groundwater.

3.2.2.3 Title V Permit

In February 2014, NYSDEC approved BNL's application to renew its Title V Permit that was submitted in December 2012 with supplemental information added in January 2013. The effective date of the five-year renewal permit is February 4, 2014. The renewed Title V Permit covers 13 emission units encompassing 130 emission sources, wherein the emission sources are grouped together because they are subject to one or more common Clean Air Act regulatory requirements.

3.3 NEPA ASSESSMENTS

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made.

During 2014, environmental evaluations were completed for 134 proposed projects at BNL. Of those, 127 were considered minor actions requiring no additional documentation. Seven projects were addressed by submitting notification forms to DOE, which determined that all seven projects were covered by existing "Categorical Exclusions" (per 10 CFR 1021) or fell within the scope of a previous environmental assessment.

3.4 PRESERVATION LEGISLATION

The Laboratory is subject to several cultural resource laws, most notably the National Historic Preservation Act and the Archeological

Resource Protection Act. These laws require agencies to consider the effects of proposed federal actions on historic structures, objects, and documents, as well as cultural or natural places important to Native Americans or other ethnic or cultural groups.

BNL has three structures or sites that are eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I Army training trenches associated with Camp Upton. Several other structures of historic significance are identified in BNL's Cultural Resources Management Plan (BNL 2013), including the Brookhaven Center, and Building 120. Two other buildings, Berkner Hall and the Chemistry Building, are considered "Architecturally Significant." A Department of Interior questionnaire regarding historic and cultural resources is prepared annually. Additional activities associated with historic preservation compliance are described in Chapter 6.

3.5 CLEAN AIR ACT (CAA)

The objectives of the CAA, which is administered by EPA and NYSDEC, are to improve or maintain regional ambient air quality through operational and engineering controls on stationary or mobile sources of air pollution. Both conventional and hazardous air pollutants are regulated under the CAA.

3.5.1 Conventional Air Pollutants

The Laboratory has a variety of conventional, nonradioactive air emission sources that are subject to federal or state regulations. The following subsections describe the more significant sources, and the methods used by BNL to comply with the applicable regulatory requirements.

3.5.1.1 Boiler Emissions

BNL has four boilers (Nos. 1A, 5, 6, and 7) at the Central Steam Facility (CSF) that are subject to NYSDEC "Reasonably Available Control Technology" (RACT) requirements. Three of the boilers can burn either residual fuel oil or natural gas; Boiler 1A burns fuel oil only. In 2014, natural gas was the predominant fuel burned at the

CSF. For boilers with maximum operating heat inputs greater than or equal to 25 MMBtu/hr (7.3 MW), the RACT requirements establish emission standards for oxides of nitrogen (NO_x). On July 1, 2014, new lower NO_x RACT standards went into effect. The Laboratory also maintains continuous opacity monitors for Boilers 6 and 7.

On July 17, 2014, Boiler 6 exceeded the new NO_x RACT limit of 0.15 lbs/MMBtu with a 24-hour average emission rate of 0.21 lbs/MMBtu while firing No. 6 oil. The exceedance occurred after natural gas service was interrupted to the CSF to permit modifications of natural gas line utility services. This exceedance was documented in the quarterly Site-Wide Air Emissions and Monitoring Systems Performance Report submitted to NYSDEC. Also in 2014, on November 25, there was one excess opacity measurement recorded by Boiler 6 during scheduled service work on the continuous opacity system, and five excess opacity measurements recorded by Boiler 7.

All of the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to NYSDEC. Chapter 4 discusses CSF compliance with NO_x RACT standards and opacity limits in greater detail.

3.5.1.2 Ozone-Depleting Substances

Refrigerant: The Laboratory's preventative maintenance program requires regular inspection and maintenance of refrigeration and air conditioning equipment that contains ozone-depleting substances such as R-11, R-12, and R-22. All refrigerant recovery and recycling equipment is certified to meet refrigerant evacuation levels specified by 40 CFR 82.158. As a matter of BNL's standard practice, if a refrigerant leak is found, technicians will either immediately repair the leak or isolate it and prepare a work order for the needed repairs. This practice is more stringent than the leak repair provisions of 40 CFR 82.156.

In 2014, 21 pounds of R-12, 420 pounds of R-22, and 47 pounds of R-123 were recovered and recycled from refrigeration equipment that was serviced. Four hundred pounds of R-11, 780 pounds of R-22, 6 pounds of R-134a, 41 pounds of R-401a, and 42 pounds of R-410A

leaked from refrigeration and air conditioning equipment on site. These leaks were subsequently reported as emissions in an Annual Emissions Statement transmitted to NYSDEC.

Halon: Halon 1211 and 1301 are extremely efficient fire suppressants, but are being phased out due to their effect on the earth's ozone layer. In 1998, the Laboratory purchased equipment to comply with the halon recovery and recycling requirements of the CAA, 40 CFR 82 Subpart H. When portable fire extinguishers or fixed systems are removed from service and when halon cylinders are periodically tested, Laboratory technicians use halon recovery and recycling devices to comply with CAA provisions. Halon recovered from excessed systems is stored for reuse by BNL or shipped to the Department of Defense Ozone Depleting Substances Reserve.

In 2014, there were no discharges of Halon 1211 from portable fire extinguishers or Halon 1301 from accidental or fire-induced activation of fixed fire suppression systems. There were also no Laboratory transfers of excess ozone depleting substances to the Ozone Depleting Substances Reserve. Plans for 2015 include the transfer of excess cylinders of Halon 1301 from three fixed fire suppression systems scheduled for removal, recovering R-11 from two centrifugal chillers scheduled to be decommissioned, and the transfer of several cylinders of excess R-12 and R-22, and nine 1-pint bottles of unused CFC-113 to the Ozone Depleting Substances Reserve. The transfer will be made in accordance with the Class I Ozone Depleting Substances Disposition Guidelines prepared by the DOE Office of Environmental Policy and Guidance.

3.5.2 Hazardous Air Pollutants

In 1970, the CAA established standards to protect the general public from hazardous air pollutants that may lead to death or an increase in irreversible or incapacitating illnesses. The NESHAPs program was established in 1977 and the governing regulations were updated significantly in 1990. EPA developed NESHAPs to limit the emission of 189 toxic air pollutants. The program includes a list of regulated contaminants, a schedule for implementing control requirements, aggressive technology-based

emission standards, industry-specific requirements, special permitting provisions, and a program to address accidental releases. The following subsections describe BNL's compliance with NESHAPs regulations.

3.5.2.1 Maximum Available Control Technology

In 2011, the Laboratory had determined that its four CSF boilers were subject to the work practice standards and management practices of 40 CFR 63 Subpart JJJJJ NESHAPs for Industrial, Commercial, and Institutional Boilers and Area Sources, requiring a one-time energy assessment of the boilers be performed no later than March 21, 2014. The objective of the energy assessment was to produce a comprehensive report with a list of recommendations to improve boiler combustion efficiencies and potential energy savings measures. Following the completion of the energy assessment in March, a copy of the engineering report was transmitted to the EPA Region 2 office on June 29, 2014.

3.5.2.2 Asbestos

In 2014, the Laboratory notified the EPA Region II office regarding the removal of materials containing asbestos. During the year, 1,250 linear feet of pipe insulation and 750 square feet of non-friable (e.g., floor tiles, siding material) materials were removed and disposed of according to EPA requirements.

3.5.2.3 Radioactive Airborne Emissions

Minor and major sources of radiological airborne emissions from BNL's facilities and activities are evaluated to ensure that they do not impact the environment, on-site workers, or people residing at or near the Laboratory. A full description of radiological emissions monitoring conducted in 2014 is provided in Chapter 4.

BNL transmitted all data pertaining to radioactive air emissions and dose calculations to EPA in fulfillment of the June 30 annual reporting requirement. As in past years, the maximum off-site dose due to airborne radioactive emissions from the Laboratory continued to be far below the 10 mrem (100 μ Sv) annual dose limit specified in 40 CFR 61 Subpart H (see Chapters

4 and 8 for more information on the estimated air dose). Using EPA modeling software, the dose to the maximally exposed off-site individual resulting from BNL's airborne emissions in 2014 was 2.85 E-01 mrem (2.85 μ Sv).

3.6 CLEAN WATER ACT

The disposal of wastewater generated by Laboratory operations is regulated under the Clean Water Act (CWA) as implemented by NYSDEC and under DOE Order 458.1, *Radiation Protection of the Public and the Environment*. The goals of the CWA are to achieve a level of water quality that promotes the propagation of fish, shellfish, and wildlife; to provide waters suitable for recreational purposes; and to eliminate the discharge of pollutants into surface waters. New York State was delegated CWA authority in 1975. NYSDEC has issued a SPDES permit to BNL that regulates wastewater effluents. The permit specifies monitoring requirements and effluent limits for 9 of 12 outfalls, as described below. See Figure 5-2 in Chapter 5 for the locations of BNL outfalls.

- Outfall 001 is used to discharge treated effluent from the STP to groundwater via recharge basins (starting in October 2014).
- Outfalls 002, 002B, 003, 005, 006A, 006B, 008, 010, 011, and 012 are recharge basins used to discharge cooling tower blow-down, once-through cooling water, and/or stormwater. Since only stormwater or once-through cooling water is discharged to Outfalls 003, 011, and 012, NYSDEC imposes no monitoring requirements for these discharges.
- Outfall 007 receives backwash water from the Potable Water Treatment Plant filter building.
- Outfall 009 consists of numerous subsurface and surface wastewater disposal systems (e.g., drywells) that receive predominantly sanitary waste and steam- and air-compressor condensate discharges. NYSDEC does not require monitoring of these disposal systems.

Each month, the Laboratory prepares Discharge Monitoring Reports that describe monitoring results, evaluate compliance with permit

limitations, and identify corrective measures taken to address permit excursions. These reports are submitted to NYSDEC central and regional offices and the SCDHS. Details of the monitoring program conducted for the groundwater treatment systems where SPDES equivalency permits are in effect are provided in SER Volume II, *Groundwater Status Report*. Evaluation of the current effluent quality shows it to consistently meet all groundwater effluent standards, and in most cases, ambient water quality standards for groundwater.

As stated in Section 3.2.2.1, BNL received approval on its SPDES Permit Renewal application in September 2014, which reflected a modified treatment process that replaced the STP sand filters with free standing self-enclosed filtration units and diverted the discharge to on-site recharge basins. Construction of the new filtration units was completed in September 2014 and the system was placed into operation during the first week of October 2014.

Details on monitoring results, evaluation of compliance with permit limits, and description of any corrective actions taken to address permit excursions are provided in the following sections.

3.6.1 Sewage Treatment Plant

Sanitary and process wastewater generated by BNL operations is conveyed to the STP for processing before discharge to groundwater. The STP provides tertiary treatment of the wastewater and includes the following processes: settling/sedimentation, biological reduction of organic matter and nitrogen, and final filtration. Chapter 5 provides a detailed description of the treatment process.

A summary of SPDES monitoring results for the STP discharge at Outfall 001 is provided in Tables 3-3 (Peconic River) and 3-4 (Groundwater), along with relevant SPDES permit limits. Two tables are provided because STP discharge at Outfall 001 was to the Peconic River from January 1, 2014 to September 30, 2014 and then to groundwater discharge via recharge beds from October 1, 2014 to December 31, 2014, due to changes in the Laboratory's SPDES permit. Relevant SPDES permit limits are provided

in both tables because there were some changes to analytes and associated permit limits. The Laboratory monitors the STP discharge for more than 100 parameters monthly and more than 200 parameters quarterly. BNL's overall compliance with effluent limits was greater than 99 percent in 2014.

There were four excursions of the SPDES permit limits at Outfall 001 in 2014: two for mercury and two for total nitrogen. In January, a grab sample exhibited a mercury concentration of 54 ng/L, which was just above the permit limit of 50 ng/L. A grab sample collected in August exhibited a mercury concentration of 115 ng/L, which at that time, was just above the SPDES permit limit of 100 ng/L. The SPDES Permit issued by NYSDEC on June 9, 2009 included a mercury limit of 50 ng/l and requirements to conduct a mercury minimization program. An interim mercury limit of 200 ng/L was in effect until September 30, 2012, while the Laboratory implemented a mercury minimization program with the goal of achieving the mercury limit of 50 ng/L.

BNL prepared and implemented an extensive mercury minimization program, which included summarizing past minimization efforts and staff training prior to 2009. As part of these earlier efforts, lab sink traps and piping had been cleaned out on several occasions since 1992. Glass piping was installed in some of the chemistry labs so that mercury deposits could be located visually and removed. Under the new SPDES permit requirements, additional source investigations were conducted and a pilot study using a mercury release compound followed by rinsing and collection of the wastewaters to remove legacy contamination at one laboratory building was performed. Approximately 90 sink traps and 900 linear feet of waste piping have been replaced as part of recent science building renovations. BNL continues efforts to reduce the on-site inventory of elemental mercury and mercury-containing equipment. All of these efforts have resulted in mercury concentration reductions measured at the STP outfall.

Concurrent to the mercury removal efforts, BNL was also required to conduct a Quantification & Removal Study with the goal of

CHAPTER 3: COMPLIANCE STATUS

identifying controllable sources of copper, iron, lead, nickel, and zinc for treatment or alternate disposal. This was a result of the SPDES Permit evaluation which included more stringent water quality-based effluent limits for these metals.

The Quantification & Removal Study did not identify controllable sources of these metals and, as reported in previous Site Environmental Reports, the Laboratory evaluated several treatment and disposal options and ultimately

Table 3-3. Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001 (Peconic River).

Analyte	Low Report	High Report	Min. Monitoring. Freq.	SPDES Limit	Exceedances	% Compliance*
Max. temperature (°F)	45	77	Daily	90	0	100
pH (SU)	6.5	7.9	Continuous Recorder	Min 5.8, Max. 9.0	0	100
Max. 5-Day BOD (mg/L)	<2	<2	Twice Monthly	5	0	100
% BOD Removal	> 89	> 99	Monthly	85	0	100
Max. TSS (mg/L)	<0.6	<1.0	Twice Monthly	20	0	100
% TSS Removal	> 98	>99	Monthly	85	0	100
Settleable solids (ml/L)	0	0	Daily	0.1	0	100
Ammonia nitrogen (mg/L)	< 0.1	0.7	Twice Monthly	1.5	0	100
Total nitrogen (mg/L)	1.9	11.9 (a)	Twice Monthly	10	2	93
Total nitrogen (lbs./day)	9	16	(May – October)	20	0	100
Total phosphorus (mg/L)	0.9	1.6	Twice Monthly	NA	0	100
Cyanide (mg/L)	< 0.002	0.009	Twice Monthly	0.1	0	100
Copper (mg/L)	0.012	0.042	Twice Monthly	0.15	0	100
Iron (mg/L)	0.049	0.264	Twice Monthly	0.37	0	100
Lead (mg/L)	0.001	0.002	Twice Monthly	0.019	0	100
Mercury (ng/L)	29	115 (b)	Twice Monthly	50/100 (c)	2	100
Methylene chloride (ug/L)	1.3	< 2	Twice Monthly	5	0	100
Nickel (mg/L)	<0.002	0.004	Twice Monthly	0.11	0	100
Silver (mg/L)	< 0.001	<0.01	Twice Monthly	0.015	0	100
Toluene (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Zinc (mg/L)	0.013	0.057	Twice Monthly	0.1	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
2-butanone (ug/L)	< 5	< 5	Twice Monthly	50	0	100
Chlorine, Total Residual (mg/L)	0.02	0.05	Weekly	0.05	0	100
Max. Flow (MGD)	0.29	0.75	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.23	0.49	Continuous Recorder	NA	0	100
Avg. Fecal Coliform (MPN/100 ml)	<2	7	Twice Monthly	200	0	100
Max. Fecal Coliform (MPN/100 ml)	<2	17	Twice Monthly	400	0	100
HEDP (mg/L)	<0.05	0.59	Monthly	NA	0	100
Tolytriazole (mg/L)	< 0.005	< 0.005	Monthly	NA	0	100

Notes:

See Figure 5-2 for location of Outfall 001 (Groundwater).

* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100

BOD = biological oxygen demand

HEDP = 1-hydroxyethylidene diphosphonic acid

MGD = million gallons per day

NA = Not Applicable

SPDES = State Pollutant Discharge Elimination System

SU = standard unit

TSS = total suspended solids

(a) Two permit exceedances for total nitrogen were reported in March (see Section 3.6.1 for an explanation of this permit exceedance).

(b) Two permit exceedances for mercury were reported in January and August.

(c) Mercury limit in January and February was 50 ng/L. The limit from March to September was 100 ng/L.

chose to relocate the treatment plant discharge from the Peconic River to newly constructed groundwater recharge basins. BNL submitted a May 18, 2012, SPDES Permit modification for the relocation of this discharge and to modify the interim mercury limit from 200 ng/L to 100 ng/L until the recharge basins were constructed in 2014.

Because the SPDES Permit modification had

not yet been issued by NYSDEC in September 2012, BNL was granted an extension of the interim mercury limit of 200 ng/L for six months or until the permit modification was completed, whichever came first. Because of delays in issuing this permit modification, the interim limit expired on March 31, 2013, and the mercury limit became 50 ng/L. Upon issuance of the Laboratory's permit modification in March 2014, the

Table 3-4. Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001 (Groundwater).

Analyte	Low Report	High Report	Min. Monitoring Freq.	SPDES Limit	Exceedances	% Compliance*
pH (SU)	6.5	7.9	Continuous Recorder	Min 5.8, Max. 8.5	0	100
Max. 5-Day BOD (mg/L)	<2	<2	Twice Monthly	5	0	100
% BOD Removal	> 89	> 96	Monthly	85	0	100
Max. TSS (mg/L)	<0.6	1.5	Twice Monthly	20	0	100
% TSS Removal	> 98	>99	Monthly	85	0	100
Settleable solids (ml/L)	0	0	Daily	0.1	0	100
Solids, Total Dissolved (mg/L)	151	234	Monthly	1000	0	100
Ammonia nitrogen (mg/L)	0.3	1.7	Twice Monthly	2	0	100
Total nitrogen (mg/L)	7.1	8	Twice Monthly	10	0	100
Total phosphorus (mg/L)	1	1.5	Twice Monthly	NA	0	100
Cyanide (mg/L)	< 0.002	<0.002	Twice Monthly	0.1	0	100
Copper (mg/L)	0.025	0.042	Twice Monthly	0.15	0	100
Iron (mg/L)	0.2	0.26	Twice Monthly	0.6	0	100
Lead (mg/L)	0.00062	0.00086	Twice Monthly	0.025	0	100
Mercury (ng/L)	8	35	Twice Monthly	200	0	100
Methylene chloride (ug/L)	<2	< 2	Twice Monthly	5	0	100
Nickel (mg/L)	0.002	0.003	Twice Monthly	0.1	0	100
Silver (mg/L)	< 0.001	<0.001	Twice Monthly	0.015	0	100
Toluene (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Zinc (mg/L)	0.05	0.06	Twice Monthly	2	0	100
1,1,1-trichloroethane (ug/L)	< 1	< 1	Twice Monthly	5	0	100
Max. Flow (MGD)	0.46	0.61	Continuous Recorder	2.3	0	100
Avg. Flow (MGD)	0.3	0.33	Continuous Recorder	NA	0	100
HEDP (mg/L)	<0.05	<0.1	Monthly	0.5	0	100
Tolytriazole (mg/L)	< 0.005	< 0.005	Monthly	0.05	0	100

Notes:

See Figure 5-2 for location of Outfall 001 (Groundwater).

* % Compliance = total no. samples – total no. exceedances/total no. of samples x 100

BOD = biological oxygen demand

HEDP = 1-hydroxyethylidene diphosphonic acid

MGD = million gallons per day

NA = Not Applicable

SPDES = State Pollutant Discharge Elimination System

SU = standard unit

TSS = total suspended solids

interim mercury limit became 100 ng/L for the existing Outfall 001 (Peconic River) until the discharge was relocated to the recharge beds. Once the recharge beds were completed and the discharge diverted to groundwater, the mercury limit became 200 ng/L. With the new filtration system completed and in operation, effluent mercury concentrations are well below permit limits.

Composite samples collected on March 10 and 14, 2014, from Outfall 001 for routine compliance nitrogen series analysis exhibited total nitrogen concentrations of 11.9 mg/L and 11.3 mg/L, respectively. Permit limits for total nitrogen is 10 mg/L. Based on review/analysis of activated sludge by a wastewater microbiological specialist in January 2014, it appears that the pH in the STP's aeration tank was too low. Whereas the optimal pH should be 7.5 SU or greater, in February 2014, the pH was measured at 5.8 SU. Actions taken to improve this process (e.g., raising the pH in the aeration tank and adding magnesium hydroxide to help reduce the toxicity of the organic acids and other chemicals in sewage) appear to have been effective in reducing effluent total nitrogen concentrations.

Figures 3-1 through 3-7 plot the 5-year trends for monthly concentrations of copper, iron, lead, mercury, nickel, silver, and zinc in the STP discharge.

3.6.1.1 Chronic Toxicity Testing

The Laboratory's modified SPDES permit required that "whole effluent toxicity" (WET) tests continue to be conducted while discharging to the Peconic River to ensure that chemicals present in the STP effluent are not toxic to aquatic organisms. Between January and September 2014, BNL continued to perform quarterly chronic toxicity testing using water fleas (*Ceriodaphnia dubia*). In each test, sets of 10 organisms are exposed to varying concentrations of the STP effluent (100, 75, 50, 25, and 12.5 percent) for seven days. During testing, the rate of reproduction for the water flea is measured and compared to untreated organisms (i.e., controls).

Testing in 2014 showed that there was no toxicity demonstrated in the three tests performed. Reproduction and survival rates were comparable to the control population, indicating that the STP effluent was not toxic to invertebrate organisms. Under the terms of the Laboratory's most recent SPDES Permit, testing is no longer required now that STP discharge is to groundwater; consequently, testing was discontinued in October 2014.

3.6.2 Recharge Basins and Stormwater

Water discharged to Outfalls 002 through

Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2009–2014.

Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2009–2014.

Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2009–2014.

Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2009–2014.

Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2009–2014.

Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2009–2014.

Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2009–2014.

008 and Outfalls 010 through 012 recharges to groundwater, replenishing the underlying aquifer. Monitoring requirements for each of these discharges vary, depending on the type of wastewater received and the type of cooling water treatment reagents used. Table 3-5 summarizes the monitoring requirements and performance results.

There were four excursions reported for these outfalls during 2014: one pH excursion at Outfall 010, two oil and grease excursions at Outfalls 002 and 006B, and one 1-Hydroxyethylidene 1,1-Diphosphonic Acid (HEDP) excursion at Outfall 002.

A grab sample collected from Outfall 010 on April 8, 2014, following a significant rain event exhibited a pH of 10.7 SU, which exceeded the SPDES Permit level of 8.5 SU. This outfall only receives stormwater runoff from the CSF. The area immediately surrounding the CSF was under construction (i.e. future site of the Northeast Solar Energy Research Center (NSERC)), which included the addition of road base using recycled concrete aggregate (RCA), the most likely cause of the elevated pH. A follow-up sample collected at this outfall soon after the main storm event passed showed that the pH decreased and was within limits. At that time, the NSERC contractor was reminded to maintain good housekeeping at the construction site, including repairing silt fencing and filter fabric associated with catch basins connected to Outfall 010.

A grab sample collected on March 5, 2014, from Outfall 006B (HT-E) exhibited an oil and grease concentration of 19 mg/L, which was just above the permit limit of 15 mg/L. No visible observations of any sheen were identified at the time of sample collection and follow-up inspection of the outfall did not reveal any obvious oil staining. The discharges to Outfall 006B is comprised of mainly stormwater runoff. There are no once-through cooling water systems and only one active cooling tower that discharges to this outfall. The cause of this elevated oil and grease value was determined to be an isolated event and most likely runoff from parking lot discharges.

A request was made to collect a grab sample

from Outfall 002 (HN) on April 11, 2014, for oil and grease analysis after a report was made that there was a slight sheen in the discharge immediately downstream of the outfall. Results received on April 28 revealed an oil and grease concentration of 23.5 mg/L, which was above the permit limit of 15 mg/L. The slight sheen was treated as a release, and emergency spill response personnel immediately responded to the scene to initiate cleanup activities. Absorbent pads/socks were placed downstream of the outfall and a 25 foot “creek boom” was deployed to ensure the sheen was contained. Inspection of upstream inputs to this outfall did not reveal any continuous sources, indicating that this was a onetime event. A sample of the water/sheen mixture was also collected by emergency response personnel for in-field analysis. The analysis indicated that the material was propylene glycol (with 99.6 percent confidence). The initial absorbent pads/socks were placed in containers for proper disposal and new ones were left overnight to pick up any residual material. Inspection of the outfall the following day did not show any further sheen. Remaining absorbent materials were picked up and the boom was removed. Potential sources of propylene glycol were evaluated, but it appeared that the release was an isolated event from a piece of equipment or vehicle that was not identified or reported at that time.

A quarterly sample collected from Outfall 002 (HN) on April 28, 2014, exhibited a HEDP concentration of 0.57 mg/L, which was above the permit limit of 0.5 mg/L. Other permitted recharge basins sampled on the same day also exhibited elevated HEDP concentrations but were below the permit limit. These results were very unusual, and review of the past five years of quarterly sampling results show that concentrations of this compound at Outfall 002 and other permitted basins were < 0.05 mg/L, indicating that Water Treatment Chemical (WTC) residuals in the systems discharging to the outfalls are effectively controlled. The cause of the elevated HEDP is not known; however, analytical results of samples collected from Outfall 002 and other permitted recharge basins in July 2014 showed that all HEDP concentrations were < 0.07 mg/L,

indicating that this was most likely a one-time event.

3.7 SAFE DRINKING WATER ACT

The extraction and distribution of drinking water is regulated under the federal Safe Drinking Water Act (SDWA). In New York State, implementation of the SDWA is delegated to the New York State Department of Health (NYSDOH) and administered locally by SCDHS. Because BNL provides potable water to more than 25 full-time residents, it is subject to the same requirements as a municipal water supplier. Monitoring requirements are prescribed annually by SCDHS, and a Potable Water Sampling and Analysis Plan (Bruno 2014) is prepared by the Laboratory to comply with these requirements.

3.7.1 Potable Water

The Laboratory has six water supply wells for on-site distribution of potable water; five of which were active during 2014. As required by NYSDOH regulations, BNL monitors the potable wells regularly for bacteria, inorganics, organics, and pesticides. The Laboratory also voluntarily monitors drinking water supplies for radiological contaminants yearly. Tables 3-6 and 3-7 provide potable water supply monitoring data. In 2014, BNL's drinking water and the supply and distribution system was in full compliance with all applicable county, state, and federal regulations regarding drinking water quality, monitoring, operations, and reporting. In addition to the compliance sampling program, all wells are also sampled and analyzed quarterly under the Laboratory's environmental surveillance program. Data collected under this program are consistent with the data reported in Tables 3-6 and 3-7. This additional testing goes beyond the minimum SDWA testing requirements.

To ensure that consumers are informed about the quality of Laboratory-supplied potable water, in May of each year BNL publishes a Consumer Confidence Report (CCR), a deadline stipulated by the SDWA. This report provides information regarding source water, supply system, the analytical tests conducted, and detected

Table 3-5. Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010. (Continued)

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Flow (MGD)	N Min. Max.	CR 0.06 3.8	CR 0.00006 0.08	CR 0.16 0.73	CR 0.02 0.18	CR 0.05 0.33	CR 0.08 0.32	11 0.00082 1.5	11 0.0015 1.2	NA NA NA	NA	NA
pH (SU)	Min. Max.	6.7 8.6	7.1 8.3	6.5 8.4	7.1 8.9	7.0 8.9	6.9 8.6	7.2 8.5	7.3 10.7	NA 8.5, 9.0 (a)	1	98
Oil and Grease (mg/L)	N Min. Max.	13 < 1.1 23.5	11 < 1.1 3.3	12 < 1.2 4.7	12 < 1.1 1.9	12 < 1.1 19.0	NR NR NR	11 < 1.1 2.9	11 < 1.1 4.18	NA 15	2	98
Copper (mg/L)	N Min. Max.	NR NR NR	NR NR NR	4 < 0.003 (T) 0.02	NR NR NR	NR NR NR	NR NR NR	NR NR NR	4 < 0.003 (D) 0.05 (D)	NA 1.0	0	100
Aluminum (mg/L)	N Min. Max.	4 < 0.07 (T) 0.09	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	4 < 0.07 (D) 0.4 (D)	4 0.1 (D) 0.6 (D)	NA 2.0	0	100

Table 3-5. Analytical Results for Wastewater Discharges to Outfalls 002, 005 - 008, and 010. (concluded).

Analyte		Outfall 002	Outfall 002B	Outfall 005	Outfall 006A	Outfall 006B	Outfall 007	Outfall 008	Outfall 010	SPDES Limit	No. of Exceedances	% Compliance*
Lead, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4	NA 0.05	0	100
	Min.	NR	NR	NR	NR	NR	NR	NR	<0.001			
	Max.	NR	NR	NR	NR	NR	NR	NR	0.006			
Vanadium, Dissolved (mg/L)	N	NR	NR	NR	NR	NR	NR	NR	4	NA NPL	NA	NA
	Min.	NR	NR	NR	NR	NR	NR	NR	0.003			
	Max.	NR	NR	NR	NR	NR	NR	NR	0.03			
Chloroform (µg/L)	N	5	NR	NR	NR	NR	NR	NR	NR	NA 7	0	100
	Min.	< 1	NR	NR	NR	NR	NR	NR	NR			
	Max.	0.8	NR	NR	NR	NR	NR	NR	NR			
Bromodichloromethane (µg/L)	N	4	NR	NR	NR	NR	NR	NR	NR	NA 50	0	100
	Min.	< 1	NR	NR	NR	NR	NR	NR	NR			
	Max.	0.5	NR	NR	NR	NR	NR	NR	NR			
1,1,1-trichloroethane (µg/L)	N	4	NR	NR	NR	NR	NR	11	NR	NA 5	0	100
	Min.	< 1	NR	NR	NR	NR	NR	< 1	NR			
	Max.	< 1	NR	NR	NR	NR	NR	< 1	NR			
1,1-dichloroethane (µg/L)	N	NR	NR	NR	NR	NR	NR	11	NR	NA 5	0	100
	Min.	NR	NR	NR	NR	NR	NR	< 1	NR			
	Max.	NR	NR	NR	NR	NR	NR	< 1	NR			
Hydroxyethylidene-diphosphonic acid (mg/L)	N	4	NR	4	4	4	NR	NR	NR	NA 0.5	1	94
	Min.	<0.05	NR	<0.05	<0.05	<0.05	NR	NR	NR			
	Max.	0.6	NR	0.09	0.4	0.4	NR	NR	NR			
Tolyltriazole (mg/L)	N	4	NR	4	4	4	NR	NR	NR	NA 0.2	0	100
	Min.	<0.005	NR	<0.005	<0.005	<0.005	NR	NR	NR			
	Max.	<0.005	NR	<0.005	<0.005	<0.005	NR	NR	NR			

Notes:

See Figure 5-2 for location of outfalls.

There are no monitoring requirements for Outfalls 009, 011, and 012.

* % Compliance = total no. samples - total no. exceedances/total no. of samples x 100

(a) pH limit is 8.5 for Outfalls 005, 008, and 010; pH limit is 9.0 for Outfalls 002, 002B, 006A, 006B, and 007

CR = continuous recorder

D = dissolved

MGD = million gallons per day

Max. = maximum value

Min. = minimum value

N = number of samples

NA = not applicable

NPL = no permit limit: monitoring only

NR = analysis not required

SU = standard unit

T = total recoverable

contaminants are compared to federal drinking water standards. The CCR also describes the measures the Laboratory takes to protect its water source and limit consumer exposure to contaminants. The CCR is distributed to all BNL employees and on-site residents, either in paper form or electronically at <http://www.bnl.gov/water/>.

3.7.2 Cross-Connection Control

The SDWA requires that public water suppliers implement practices to protect the water supply from sanitary hazards. One of the safety requirements is to rigorously prevent cross-connections between the potable water supply and facility piping systems that may contain hazardous substances. Cross-connection control is the installation of control devices (e.g., double-check valves, reduced pressure zone valves, etc.) at the interface between a facility and the domestic water main. Cross-connection control devices are required at all facilities where hazardous materials are used in a manner that could result in their introduction into the domestic water system, especially under low-pressure conditions. In addition, secondary cross-connection controls at the point of use are recommended to protect users within a specific facility from hazards that may be posed by intra-facility operations.

During 2014, the Laboratory inspected 260 cross-connection control devices, including primary devices installed at interfaces to the potable water main, and secondary control devices at the point of use. If a problem with a cross-connection device is encountered during testing, the device is repaired and retested to ensure proper function. Copies of the cross-connection device test reports are filed with SCDHS throughout the year.

3.7.3 Underground Injection Control (UIC)

UIC wells are regulated under the SDWA. At the Laboratory, UICs include drywells, cesspools, septic tanks, and leaching pools, all of which are classified by EPA as Class V injection wells. Proper management of UIC devices is vital for protecting underground sources of drinking water. In New York State, the UIC program is implemented through EPA because NYSDEC

has not adopted UIC regulatory requirements. (Note: New York State regulates the discharges of pollutants to cesspools under the SPDES program.) Under EPA's UIC program, all Class V injection wells must be included in an inventory maintained with the agency.

At the end of 2014, BNL's total UIC inventory was 128. In June 2010, an application was filed with EPA to renew the Class V UIC permit for the site. In August 2012, BNL received a letter from EPA indicating that addition or removal of UICs from the existing inventory would be "authorized by rule," pursuant to 40 CFR §144.24; however, it is still unclear if EPA intends to renew BNL's Class V UIC permit. In addition to the UICs maintained for routine Laboratory discharges of sanitary waste and storm water, UICs also are maintained at several on- and off-site treatment facilities used for groundwater remediation. Contaminated groundwater is treated and then returned to the aquifer via drywells, injection wells, or recharge basins. Discharges to these UICs are authorized by rule rather than by permit. Under the authorized by rule requirements, a separate inventory is maintained for these treatment facilities, and is periodically updated whenever a new device is added or closed.

3.8 PREVENTING AND REPORTING SPILLS

Federal, state, and local regulations are in place to address the management of storage facilities containing chemicals, petroleum, and other hazardous materials. The regulations include specifications for the design of storage facilities, requirements for written plans relating to unplanned releases, and requirements for reporting releases that do occur. BNL's compliance with these regulations is further described in the following sections.

3.8.1 Preventing Oil Pollution and Spills

As required by the Oil Pollution Act, BNL maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as a condition of its license to store petroleum fuel. The purpose of this plan is to provide information regarding release prevention measures, the design of storage facilities, and maps detailing storage

CHAPTER 3: COMPLIANCE STATUS

Table 3-6. Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value).

Compound	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	Potable Distribution Sample	NYS DWS
Water Quality Indicators							
Ammonia (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	SNS
Chlorides (mg/L)	37.2	42.9	42.4	57.9	46.4	47.1	250
Color (units)	45*	55*	25*	< 5	< 5	<5	15
Conductivity (mmhos/cm)	208	198	211	313	320	321	SNS
Cyanide (mg/L)	< 10	< 10	< 10	< 10	< 10	< 10	SNS
MBAS (mg/L)	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	SNS
Nitrates (mg/L)	0.21	0.33	0.52	0.63	0.73	0.75	10
Nitrites (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1
Odor (units)	0	0	0	0	0	0	3
pH (Standard Units)	6	5.9	6	6.2	6	7.3	SNS
Sulfates (mg/L)	9.2	10.6	12.5	11.4	12	11.7	250
Total coliform	ND	ND	ND	ND	ND	ND	Negative
Metals							
Antimony (mg/L)	< 0.4	<0.4	<0.4	<0.4	<0.4	<0.4	6
Arsenic (mg/L)	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	50
Barium (mg/L)	0.0225	0.0318	0.0187	0.0448	0.0411	0.042	2
Beryllium (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	4
Cadmium (mg/L)	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	5
Chromium (mg/L)	0.004	0.004	<0.002	<0.002	<0.002	<0.002	0.1
Fluoride (mg/L)	<0.1	<0.1	0.19	< 0.1	< 0.1	< 0.1	2.2
Iron (mg/L)	2.3*	3.95*	1.96*	<0.018	<0.018	0.051	0.3
Lead (mg/L)	<1.0	<1.0	1.1	<1.0	<1.0	<1.0	15
Manganese (mg/L)	0.22	0.094	0.056	< 0.002	< 0.002	0.004	0.3
Mercury (mg/L)	< 0.067	< 0.067	< 0.067	< 0.067	< 0.067	< 0.2	2
Nickel (mg/L)	< 0.002	0.022	0.017	< 0.002	< 0.002	< 0.04	SNS
Selenium (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0	4.1	50
Sodium (mg/L)	22.7	20.3	24.5	30.9	25.2	39.2	SNS
Silver (mg/L)	<10	<10	<10	<10	<10	<10	100
Thallium (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2
Zinc (mg/L)	<0.003	<0.003	<0.003	<0.003	<0.003	0.0043	5
Radioactivity							
Gross alpha activity (pCi/L)	< 1.99	< 1.98	< 1.99	<1.96	<1.98	NR	15
Gross beta activity (pCi/L)	3.15 ± 1.5	<1.72	2.36 ± 1.03	3.55± 1.62	6.78 ± 1.48	NR	(a)
Radium-228 (pCi/L)	NS	NS	NS	NS	NS	NR	5
Strontium-90 (pCi/L)	< 0.77	< 0.76	< 0.79	< 0.79	< 0.79	NR	8
Tritium (pCi/L)	< 268	<267	< 268	< 262	< 268	NR	20,000
Other							
Alkalinity (mg/L)	12.7	11.3	15.5	26	20.6	54.9	SNS
Asbestos (M. fibers/L)	NR	NR	NR	NR	NR	< 0.20	7
Calcium (mg/L)	6.8	5.3	6.3	12.8	9.4	13.9	SNS
HAA5 (mg/L)	NR	NR	NR	NR	NR	0.011	0.06**
Residual chlorine - MRDL (mg/L)	NR	NR	NR	NR	NR	1.3	4
TTHM (mg/L)	NR	NR	NR	NR	NR	0.034	0.08**

Notes:

Well 12 was not operational for 2014; no testing was completed during this time.

* Water from these wells is treated at the Water Treatment Plant for color and iron reduction prior to site distribution.

** Limit imposed on distribution samples only.

(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in late 2003. Gross beta activity does not identify specific radionuclides; therefore, a dose equivalent can not be calculated. No specific nuclides were detected; therefore, compliance with the requirement is demonstrated.

HAA5 = five haloacetic acids

MBAS = methylene blue active substances

MRDL = maximum residual disinfectant level

ND = not detected

NR = analysis not required

NS = not sampled

NYS DWS = New York State Drinking Water Standard

SNS = drinking water standard not specified

TTHM = total trihalomethanes

CHAPTER 3: COMPLIANCE STATUS

Table 3-7. Potable Water Wells: Analytical Results for Principal Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables.

Compound	WTP Effluent	Well No. 4	Well No. 6	Well No. 7	Well No. 10	Well No. 11	NYS DWS
	µg/L						
Tert-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
1,2,4-trimethylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
sec-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
4-Isopropyltoluene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
n-butylbenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	5
Chloroform	1.7	1.2	2.5	1	0.83	0.73	50
Bromodichloromethane	2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Dibromochloromethane	1.8	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Bromoform	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.9	50
Methyl tert-butyl ether	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	50
Toxaphene	< 1	< 1	< 1	< 1	< 1	< 1	3
Total PCB's	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	0.5
2,4,5,-TP (Silvex)	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	< 0.13	10
Dinoseb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	50
Dalapon	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	50
Pichloram	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Dicamba	< 1	< 1	< 1	< 1	< 1	< 1	50
Pentachlorophenol	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	1
Hexachlorocyclopentadiene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5
Bis (2-ethylhexyl) Phthalate	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Bis (2-ethylhexyl) Adipate	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	50
Hexachlorobenzene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	5
Benzo (A) Pyrene	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	50
Aldicarb Sulfone	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	SNS
Aldicarb Sulfoxide	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	SNS
Aldicarb	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	SNS
Oxamyl	< 1	< 1	< 1	< 1	< 1	< 1	50
3-Hydroxycarbofuran	< 1	< 1	< 1	< 1	< 1	< 1	50
Carbofuran	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	40
Carbaryl	< 1	< 1	< 1	< 1	< 1	< 1	50
Methomyl	< 1	< 1	< 1	< 1	< 1	< 1	50
Glyphosate	< 6	< 6	< 6	< 6	< 6	< 6	50
Diquat	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	50
1,2-dibromoethane (EDB)	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05
1,2-dibromo-3-chloropropane	NR	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Lindane	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Heptachlor	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	0.4
Aldrin	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	5
Heptachlor Epoxide	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Dieldrin	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	5
Endrin	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.2
Methoxychlor	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	40
Chlordane	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
2,4,-D	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	50
Alachlor	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Simazine	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	50
Atrazine	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
Metolachlor	< 1	< 1	< 1	< 1	< 1	< 1	50
Metribuzin	< 0.5	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	50
Butachlor	< 1	< 1	< 1	< 1	< 1	< 1	50
Endothall	< 9	< 9	< 9	< 9	< 9	< 9	100
Propachlor	< 1	< 1	< 1	< 1	< 1	< 1	50

Notes:

For compliance determination with New York State Department of Health standards, potable water samples were analyzed quarterly for Principal Organic Compounds and annually for other organics by H2M Labs Inc., a New York State-certified contractor laboratory.

The minimum detection limits for principal organic compound analytes are 0.5 mg/L. Minimum detection limits for synthetic organic chemicals and micro-extractables are compound-specific, and, in all cases, are less than the New York State Department of Health drinking water standard.

Well 12 was offline and remained unused during 2014.

* Water is treated at the Water Treatment Plant prior to site distribution.

NA = not available

NR = analysis not required

SNS = drinking water standard not specified

NYS DWS = New York State Drinking Water Standard

WTP = Water Treatment Plant

facility locations. The plan also outlines mitigating and remedial actions that would be taken in the event of a major spill. BNL's SPCC Plan (Chaloupka 2011) is filed with NYSDEC, EPA, and DOE and must be updated every five years. BNL remained in full compliance with SPCC requirements in 2014.

3.8.2 Emergency Reporting Requirements

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of the Superfund Amendments and Reauthorization Act (SARA) require that facilities report inventories (i.e., Tier II Report) and releases (i.e., Tier III Report) of certain chemicals that exceed specific release thresholds. Community Right-to-Know requirements are codified under 40 CFR Parts 355, 370, and 372. Table 3-8 summarizes the applicability of the regulations to BNL. The Laboratory complied with these requirements through the submittal of reports under EPCRA Sections 302, 303, 311, 312, and 313. In fulfillment of the Tier II requirements, BNL submitted an inventory of 45 on-site chemicals (with thresholds greater than 10,000 pounds; or 500 pounds for acutely toxic materials) via the New York State approved E-Plan computer based submittal program. These chemicals ranged from road salt (1,200 tons) to nitric acid (632 pounds). To satisfy the requirements of the Tier III submittal, the Laboratory submitted its data via the EPA approved TRI-ME computer based submittal program. BNL reported releases of lead (~88,913 pounds), mercury (~51 pounds), polychlorinated biphenyls (PCBs) (~22 pounds), benzo(g,h,i)perylene (<1 pound), and polycyclic aromatic compounds (<1 pound) in 2014. Releases of lead, PCBs, and mercury were predominantly in the form of shipments of waste for off-site recycling or disposal. Releases

of benzo(g,h,i)perylene and polycyclic aromatic compounds were as byproducts of the combustion of fuel oils. In 2014, there were no releases of "extremely hazardous substances" reportable under Part 304.

3.8.3 Spills and Releases

When a spill of hazardous material occurs, Laboratory and contractor personnel are required to immediately notify the BNL Fire Rescue Group, whose members are trained to respond to such releases. Fire Rescue's initial response is to contain and control any release and to notify additional response personnel (e.g., BNL environmental professionals, industrial hygienists, etc.). Environmental professionals reporting to the scene assess the spill for environmental impact and determine if it is reportable to regulatory agencies. Any release of petroleum products to soil must be reported to both NYSDEC and SCDHS, and any release affecting surface water is also reported to the EPA National Response Center. In addition, a release of more than 5 gallons of petroleum product to impermeable surfaces or containment areas must be reported to NYSDEC and SCDHS. Spills of chemicals in quantities greater than the CERCLA-reportable limits must be reported to the EPA National Response Center, NYSDEC, and SCDHS. Remediation of the spill is conducted, as necessary, to prevent impacts to the environment, minimize human health exposures, and restore the site.

There were 28 spills in 2014, a 34 percent reduction compared to 2013. Eleven of the 28 spills met regulatory agency reporting criteria. The remaining 17 spills were small-volume releases either to containment areas or to other impermeable surfaces that did not exceed a reportable quantity. Table 3-9 summarizes each of

Table 3-8. Applicability of EPCRA to BNL.

Applicability of EPCRA to BNL				
EPCRA 302-303	Planning Notification	YES [X]	NO []	NOT REQUIRED []
EPCRA 304	EHS Release Notification	YES []	NO []	NOT REQUIRED [X]
EPCRA 311-312	MSDS/Chemical Inventory	YES [X]	NO []	NOT REQUIRED []
EPCRA 313	TRI Reporting	YES [X]	NO []	NOT REQUIRED []

the eleven reportable events, including a description of the cause and corrective actions taken. There were no long-term effects from these releases and no significant impact on the environment. All but three of the reported events were 5 gallons or less in volume. Four of the releases occurred during Laboratory construction/operational activities, either by leaks from construction equipment (i.e. backhoe, skid steer, crane, and dump truck), vehicles, or from operational equipment. The two larger-volume petroleum-based releases included a 10 gallon spill of lubricating oil from a failed pressure gauge associated with a Westinghouse motor-generator and an approximate 30-gallon release of engine oil from piping associated with a bulk oil storage tank at the Motor Pool after a Swagelok fitting failed. The one larger chemical release was approximately 100 gallons of Drew Industries Coreactant 6110 solution, which leaked into a secondary containment tray beneath a newly installed 150-gallon water treatment chemical tank in Building 600 after a corroded metal bushing on the feed pump to the tank failed.

In all instances described above, any recoverable material was removed, spill absorbents were used to remove the residual product, and all materials were collected and containerized for off-site disposal. For releases to soil, contaminated soil was removed to the satisfaction of the State inspector and containerized for off-site disposal.

3.8.4 Major Petroleum Facility (MPF) License

The storage and transfer of 2.3 million gallons of fuel oil (principally No. 6 oil) subjects the Laboratory to MPF licensing by NYSDEC. The bulk of the fuel is used at the CSF to produce high-pressure steam to heat and cool BNL facilities, and is stored in six tanks with capacities ranging from 300,000 to 600,000 gallons. The remaining storage facilities on the license range from 100 to 10,000 gallons and are located throughout the site where there is a need for building heat, emergency power, or other miscellaneous petroleum needs (motor oil, waste oil, lube oil).

There were no changes to the MPF license in 2014, which currently has 66 petroleum storage

facilities listed and expires on March 3, 2017. During 2014, BNL remained in full compliance with MPF license requirements, which include monitoring groundwater in the vicinity of the six above-ground storage tanks. The license also requires the Laboratory to inspect the storage facilities monthly, and test the tank leak detection systems, high-level monitoring, and secondary containment. Tank integrity is also checked periodically. Groundwater monitoring consists of monthly checks for the presence of floating products and twice-yearly analyses for VOCs and semi-volatile organic compounds (SVOCs). In 2014, no VOCs, SVOCs, or floating products attributable to MPF activities were detected. See SER Volume II, Groundwater Status Report, for additional information on groundwater monitoring results.

On April 17 and 18, 2014, NYSDEC conducted its annual inspection of all storage facilities included on the MPF license. Seven findings that required corrective action were identified: evaluation/repairs of the cathodic protection system for Tanks 9 and 10; need for repairs of Tank 3 secondary containment to satisfy permeability requirements for product stored; shear valve for mid-grade dispenser not installed correctly; additional cleanup required from a previously reported spill of motor oil from failed piping on Tank 423-17; completion of ten-year Out-of-Service inspections/reporting for Tanks 3 and 6; minor paint failure on shell plate of Tank 5; and the need to update BNL's Best Management Practices (BMP) Plan. Five of the seven findings were corrected in 2014 in accordance with NYSDEC directives. The remaining two findings will continue to be evaluated/addressed in 2015, and updates on progress will be provided to NYSDEC on a regular basis.

3.8.5 Chemical Bulk Storage

Title 6 of the Official Compilation of the Codes, Rules, and Regulations of the State of New York (NYCRR) Part 597 requires that all aboveground tanks larger than 185 gallons and all underground tanks that store specific chemicals be registered with NYSDEC. The Laboratory holds a Hazardous Substance Bulk Storage Registration Certificate for six tanks that store

Table 3-9. Summary of Chemical and Oil Spill Reports.

Spill No. and Date	Material/Quantity	ORPS Report	Source/Cause and Corrective Actions
14-02 01/16/14	Hydraulic Fluid/ 0.5 gallons	No	Hydraulic fluid leaked onto soil beneath a skid steer loader at the Transfer Station off of Princeton Avenue when a hydraulic line failed. The absorbent pads set beneath the loader to capture the dripping fluid and contaminated soil were placed into two 55-gallon drums for off-site disposal.
14-05 03/20/14	Lubrication Oil/ 10 gallons	No	During morning rounds, Collider Accelerator staff noticed oil leaking from a pressure gauge above a Westinghouse Motor-Generator lubricating oil tank in Building 911 and into the secondary containment vault housing the tank. After closing a valve to stop the leak, oil adsorbent pads and Simple Green degreaser were used to wipe down the sidewall of the tank, the vault floor, and other tank appurtenances coated with oil from the leak. Oil contaminated pads were placed into a 55-gallon drum for off-site disposal. Approximately 20 gallons of water that had accumulated in the vault due to a prior steam pipe leak and subsequently contaminated by the leaking oil was siphoned from the vault floor into another 55-gallon drum for off-site disposal.
14-08 04/10/14	Sodium Hypochlorite/ 100 gallons	No	Approximately 100 gallons of Drew Industries Coreactant 6110 solution leaked into a secondary containment tray beneath a newly installed 150-gallon water treatment tank in Building 600 when a corroded metal bushing on the feed pump to the tank failed. After the contractor responsible for installing the treatment tank was contacted, responding staff isolated the leak, repaired the feed pump, and pumped the product back into the treatment tank.
14-09 04/11/14	Propylene Glycol/ <1 gallon	No	During scheduled State Pollutant Discharge Elimination System (SPDES) Permit sampling at Outfall HN, a slight yellow/brown oil sheen was evident in standing water before and after the weir. Fire Rescue personnel responded and used oil absorbent pads on the water before and after the weir to capture the floating product. To prevent migration of the oil sheen, a 25-foot creek boom, roughly 40 feet downstream from the weir, was also inserted. Analysis of a sample of the water/sheen mixture processed via a portable Fourier Transform Infrared Spectroscopy (FT-IR) revealed with 99.6 percent confidence that the oily sheen was propylene glycol. A subsequent grab sample collected from the outfall was analyzed and found to have an oil and grease concentration of 23.5 mg/L. Because the result was above the SPDES limit of 15 mg/l, it was reported to the New York State Department of Environmental Conservation in the April Discharge Monitoring Report. Additional oil pads were used overnight to recover any oily residue passing through the weir. No visible sheen was observed in standing water in an inspection of the outfall the following day.
14-10 04/13/14	Engine Oil/ <30 gallons	No	After plumbers re-piped the overhead connections from the bulk oil storage tank to the oil fill guns in the Building 423 Fleet Service Shop, a Swagelok fitting failed causing the release of pressurized oil into the shop area. The oil also breached the overhead door and flowed down an incline onto Princeton Avenue, continuing west until it drained into soil adjacent to the road. Fire Rescue personnel applied speedy-dry and other absorbent materials to the pavement and impacted soil. Grounds personnel worked the speedy-dry into crevices with brooms and the contaminated absorbent was recovered by a street sweeper. Contaminated soil was dug out by hand and with a skid-steer backhoe and deposited in a 20-cubic yard dumpster. Collected speedy-dry and absorbent pads were transferred into three 55-gallon drums for off-site disposal.
14-15 06/04/14	Gear Oil/ <1 gallon	No	During an Environmental Occupational Safety and Health audit of the NSLS-II complex, soil contamination from a past spill was spotted on the asphalt pavement and soil adjacent to the nitrogen tanks east of Building 745. Based on oil staining within the space of tire tracks leading to the nitrogen tanks, it appeared that gear oil had leaked from a contractor vehicle. Speedy-dry was applied to the stained area of the pavement and the contaminated speedy-dry was placed in a 55-gallon drum along with the oil stained soil.
14-18 06/25/14	Hydraulic Fluid/ 0.5 gallons	No	As shielding blocks were being moved to the rear of Building 933 with a Bay Crane, a hydraulic hose sprayed oil onto recycled crushed aggregate (RCA). The contaminated RCA was excavated by hand and placed into a 55-gallon drum for off-site disposal and the failed hose was replaced.
14-19 07/09/14	Hydraulic Fluid/ 3.5 quarts	No	While planting trees along the median and sides of Upton Road and Princeton Avenue, hydraulic fluid began leaking from a loose hydraulic fitting on a BNL backhoe. Grounds personnel placed the contaminated soil in a 55-gallon drum for off-site disposal. The backhoe was transported to the Heavy Equipment Shop for repairs.
14-24 10/27/14	Diesel Fuel/ <1 gallon	No	During morning daily rounds/inspections, Central Steam Facility personnel observed fluid leaking from a contractor vehicle onto the gravel road just east of Tank No. 6 in the Major Petroleum Facility. A containment tray was placed beneath the leaking fuel line to collect dripping fuel while the leaking fitting was temporarily wrapped in plastic and refastened to the fuel line. The contractor recovered the stained gravel and placed it in a 5-gallon pail that was later transferred to Waste Management for off-site disposal.
14-26 11/17/14	Hydraulic Fluid/ 0.5 gallons	No	As a BNL dump truck was unloading soil at the waste transfer center, hydraulic fluid started leaking from the truck's hydraulic lift reservoir. The driver reported the leak to the Fleet Services Supervisor and Fleet Services personnel responded and placed a tray beneath the reservoir to capture the dripping fluid. Absorbent pads were also placed onto the gravel bed to capture the fluid. The residual product in the reservoir was drained and containerized before the vehicle was driven back to Fleet Services for repairs. The contaminated gravel and soiled absorbent pads were containerized and transferred to Waste Management for off-site disposal.

(continued).

Table 3-9. Summary of Chemical and Oil Spill Reports. *(concluded)*.

Spill No. and Date	Material/Quantity	ORPS Report	Source/Cause and Corrective Actions
14-28 12/04/14	Sulfuric Acid/ 0.5 liters	Yes	A waste container of Piranha Etch solution (3 parts 98 percent sulfuric acid to 1 part hydrogen peroxide) ruptured when an organic solvent added to the container caused an unanticipated chemical reaction. The solution splattered onto the floor and adjoining walls in the Center for Functional Nanomaterials (CFN) clean room where the spill occurred. Off-gasses from the reaction triggered the Highly Toxic Gas Alarms in the clean room, alerting CFN occupants to evacuate the building. Responding emergency personnel inadvertently walked through the spilled solution spreading contamination to other floor areas. Waste Management personnel used rags and a mixture of acid neutralizer and water to wipe down floor areas contaminated by the emergency responders and the wall surfaces contaminated by splattered solution. An alkaline cleaning solution was used to clean up the majority of the floor.

Notes:

ORPS = Occurrence Reporting and Processing System

treatment chemicals for potable water (sodium hydroxide and sodium hypochlorite). The tanks range in capacity from 200 to 1,000 gallons. In June 2013, BNL renewed its Chemical Bulk Storage Registration in accordance with NYSDEC directives and received a Hazardous Substance Bulk Storage Registration Certificate, which will not expire until July 27, 2015.

NYSDEC conducted an inspection of the Chemical Bulk Storage facilities in April 2014. One finding related to the integrity of the containment systems for truck transfer areas for Tanks 634-02 and 635-04 was identified. The containment systems were thoroughly inspected and repairs were made to stress cracks in accordance with NYSDEC directives.

3.8.6 County Storage Requirements

Article 12 of the Suffolk County Sanitary Code regulates the storage and handling of toxic and hazardous materials in aboveground or underground storage tanks, drum storage facilities, piping systems, and transfer areas. Article 12 specifies design criteria to prevent environmental impacts resulting from spills or leaks, and specifies administrative requirements such as identification, registration, and spill reporting procedures. In 1987, the Laboratory entered into a voluntary Memorandum of Agreement with SCDHS, in which DOE and BNL agreed to conform to the environmental requirements of Article 12. In April 2010, due to a directive from NYSDEC asserting their sole jurisdiction over petroleum storage at Major Oil Storage Facilities (MOSF), SCDHS notified BNL that they will cease permitting activities (review/approval

for new construction and modifications, issuance of operating permits, and registration requirement) for all petroleum bulk storage facilities. In 2011, the Laboratory received further information that indicated SCDHS had ceased applying Article 12 requirements to both petroleum and chemical storage at BNL regardless of whether the storage is regulated by NYSDEC. Currently, there are approximately 120 active storage facilities that are not regulated by NYSDEC that would normally fall under SCSC Article 12 jurisdiction. This includes storage of wastewater and chemicals, as well as storage facilities used to support BNL research.

To ensure that storage of chemicals and petroleum continue to meet Article 12 requirements, BNL will continue to abide by the original 1987 agreement with Suffolk County and will maintain conformance with applicable requirements of Article 12. These requirements include design, operational, and closure requirements for current and future storage facilities. The Laboratory will no longer submit new design plans for SCDHS review/approval or continue to perform other administrative activities such as registration of exempt facilities and updates of shared databases. BNL will continue to inspect all storage facilities to ensure operational requirements of SCSC Article 12 are maintained.

3.9 RCRA REQUIREMENTS

The Resource Conservation and Recovery Act regulates hazardous wastes that, if mismanaged, could present risks to human health or the environment. The regulations are designed to ensure that hazardous wastes are managed

from the point of generation to final disposal. In New York State, EPA delegates the RCRA program to NYSDEC, with EPA retaining an oversight role. Because the Laboratory may generate greater than 1,000 Kg (2,200 pounds) of hazardous waste in a month, it is considered a large-quantity generator, and has a RCRA permit to store hazardous wastes for up to one year before shipping the wastes off site to licensed treatment and disposal facilities. As noted in Chapter 2, BNL also has a number of satellite accumulation and 90-day waste storage areas. Included with the hazardous wastes regulated under RCRA are mixed wastes which are generated in small quantities at BNL. Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. In 2014, EPA performed an unannounced inspection of Hazardous Waste activities at BNL; there were no findings.

3.10 POLYCHLORINATED BIPHENYLS

The storage, handling, and use of PCBs are regulated under the Toxic Substance and Control Act. Capacitors manufactured before 1970 that are believed to be oil filled are handled as if they contain PCBs, even when that cannot be verified from the manufacturer's records. All equipment containing PCBs must be inventoried, except for capacitors containing less than 3 pounds of dielectric fluid and items with a concentration of PCB source material of less than 50 parts per million. Certain PCB-containing articles or PCB containers must be labeled. The inventory is updated by July 1 of each year. The Laboratory responds to any PCB spill in accordance with standard emergency response procedures. BNL was in compliance with all applicable PCB regulatory requirements during 2014. The Laboratory has aggressively approached reductions in its PCB inventory, reducing it by more than 99 percent since 1993. The only known regulated PCB-contaminated electrical equipment remaining on site is a one-of-a-kind klystron located in BNL's Chemistry Department.

3.11 PESTICIDES

The storage and application of pesticides (insecticides, rodenticides, herbicides, and

algicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act. BNL uses an Integrated Pest Management (IPM) plan that was developed over a decade ago, and subsequently audited by a third party during 2012. Pesticides are used at the Laboratory to control undesirable insects, mice, and rats; microbial growth in cooling towers; and to maintain certain areas free of vegetation (e.g., around fire hydrants and inside secondary containment berms). Insecticides are also applied in research greenhouses on site. Herbicide use is minimized wherever possible (e.g., through spot treatment of weeds). All pesticides are applied by BNL-employed, New York State-certified applicators. By February 1, each applicator files an annual report with NYSDEC detailing insecticide, rodenticide, algicide, and herbicide use for the previous year.

3.12 WETLANDS AND RIVER PERMITS

As noted in Chapter 1, portions of the site are situated in the Peconic River floodplain. Portions of the Peconic River are listed by NYSDEC as "scenic" under the Wild, Scenic, and Recreational River Systems Act. The Laboratory also has six areas regulated as wetlands and a number of vernal (seasonal) pools. Construction or modification activities performed within these areas require permits from NYSDEC.

Activities that could require review under the BNL Natural and Cultural Resource Management Programs (BNL 2011 and BNL 2013a) are identified during the NEPA process (see Section 3.3). In the preliminary design stages of a construction project, design details required for the permit application process are specified. These design details ensure that the construction activity will not negatively affect the area, or if it does, that the area will be restored to its original condition. When design is near completion, permit applications are filed. During and after construction, the Laboratory must comply with the permit conditions.

In 2012, BNL submitted a permit package to NYSDEC for the construction of recharge basins associated with upgrades to the STP as required by wetlands regulations and the Wild, Scenic, and Recreational River Systems Act.

The upgrades for the STP allow for the discharge of the tertiary treated wastewater directly to groundwater, and removal of the former chlorine house and UV light disinfection system. A 2011 permit for the installation of fencing and air conditioning platforms at the RHIC facility continues to remain open, pending completion of work. In addition, a permit prepared by BNL for the LISF continues to be open, and will be closed once vegetation is established throughout the solar farm and invasive plants in a modified tiger salamander habitat are under control.

3.13 PROTECTION OF WILDLIFE

3.13.1 Endangered Species Act

The Laboratory updates its list of endangered, threatened, and species of special concern (see Table 6-1 in Chapter 6) as data from state and federal sources are provided. There are no federally recognized endangered species on the BNL site. However, in October 2013 the U.S. Fish & Wildlife Service published a notice in the Federal Register proposing the listing of the Northern Long-eared Bat (*Myotis septentrionalis*) as a federally endangered species. This species is known to utilize the BNL site during the summer months. Therefore, BNL began consideration of management options to protect this species in preparation for its eventual listing, now expected in early 2015. The northern long-eared bat will be the first federally listed species known to be present at the Laboratory. State recognized endangered (E) or threatened (T) species include: eastern tiger salamander (E), persius duskywing (E), crested fringed orchid (E), Engelman spikerush (E), dwarf huckleberry (E), whorled loosestrife (E), fireweed (E), Swamp darter (T), Banded Sunfish (T), frosted elfin (T), little bluet (T), scarlet bluet (T), pine barrens bluet (T), northern harrier (T), stargrass (T), eastern showy aster (T), and stiff-leaved goldenrod (T). Although the tiger salamander is no longer the only state endangered species found at the Laboratory, it is the most notable and best-studied species on site. Tiger salamanders are listed as endangered in New York State because populations have declined due to habitat loss through development, road mortality during breeding migration, introduction of

predatory fish into breeding sites, historical collection for the bait and pet trade, water level fluctuations, pollution, and general disturbance of breeding sites.

The BNL Natural Resource Management Plan (NRMP) (BNL 2011) formalizes the strategy and actions needed to protect 26 confirmed tiger salamander breeding locations on site. The strategy includes identifying and mapping habitats, monitoring breeding conditions, improving breeding sites, and controlling activities that could negatively affect breeding. As part of environmental benefits associated with the LISF, a small tiger salamander habitat was modified to ensure improved water retention for longer periods of time.

Banded sunfish and swamp darter are found in the Peconic River drainage areas on site. Both species are listed as threatened within New York State, with eastern Long Island having the only known remaining populations of these fish in New York. Measures taken, or being taken, by the Laboratory to protect the banded sunfish and swamp darter and their habitats include: eliminating, reducing, or controlling pollutant discharges; reducing nitrogen loading in the Peconic River; monitoring populations and water quality to ensure that habitat remains viable; and minimizing disturbances to the river and adjacent banks.

Three butterfly species that are endangered, threatened, or of special concern have been historically documented at the Laboratory. These include the frosted elfin, persius duskywing, and the mottled duskywing. None have been documented in recent surveys. Habitat for the frosted elfin and persius duskywing exists on Laboratory property and the mottled duskywing is likely to exist on site; therefore, management of habitat and surveys for the three butterflies has been added to the NRMP.

Surveys for damselflies and dragonflies conducted periodically during the summer months confirmed the presence of one of the three threatened species of damselflies expected to be found on site. The pine-barrens bluet, a threatened species, has been documented at one of the many coastal plain ponds at BNL.

The Laboratory is also home to 14 species that are listed as species of special concern.

Such species have no protection under the state endangered species laws, but may be protected under other state and federal laws (e.g., Migratory Bird Treaty Act). New York State monitors species of special concern and manages their populations and habitats, where practical, to ensure that they do not become threatened or endangered. Species of special concern found at BNL include the mottled duskywing butterfly, marbled salamander, eastern spadefoot toad, spotted turtle, eastern box turtle, eastern hognose snake, worm snake, horned lark, whip-poor-will, vesper sparrow, grasshopper sparrow, red-headed woodpecker, osprey, sharp-shinned hawk, and Cooper's hawk. The management efforts for the tiger salamander also benefit the marbled salamander. At present, no protective measures are planned for the eastern box turtle or spotted turtle, as little activity occurs within their known habitat at the Laboratory. However, BNL is working with Hofstra University to study reproductive strategies and habitat use of the eastern box turtle, and it is a focal species for study within the LISF. Results of these studies may show the need for conservation and management needs. BNL continues to evaluate bird populations as part of the management strategy outlined in the NRMP.

The Laboratory has 28 plant species that are protected under state law: four are endangered plants, the Engelman spikerush, dwarf huckleberry, whorled loosestrife, and crested fringed orchid; two are threatened plants, the stiff-leaved goldenrod and stargrass; and four are rare plants, the small-flowered false foxglove, narrow-leaved bush clover, wild lupine, and long-beaked baldrush. The other 18 species are considered to be "exploitably vulnerable," meaning that they may become threatened or endangered if factors that result in population declines continue. These plants are currently sheltered due to the large areas of undeveloped pine-barren habitat on site. An additional five species are considered to be likely present or possible due to presence of correct habitat. As outlined in the NRMP, locations of these rare plants must be determined, populations estimated, and management requirements established. In an effort to locate and document rare plants, BNL is working with a botanist to

assess the flora found on site. See Chapter 6 for further details.

3.13.2 Migratory Bird Treaty Act

As mentioned in Chapter 1, the Laboratory has identified more than 185 species of migratory birds since 1948; of those, approximately 85 species nest on site. Under the Migratory Bird Treaty Act, migratory birds are protected from capture, harassment, and destruction or disturbance of nests without permits issued by the U.S. Fish and Wildlife Service. In the past, migratory birds have caused health and safety issues, especially through the deposition of fecal matter and the bird's assertive protection of nesting sites. When this occurs, proper procedures are followed to allow the birds to nest and preventive measures are taken to ensure that they do not cause problems in the future (e.g., access to nesting is closed or repaired, and/or deterrents to nesting are installed). Canada geese (*Branta canadensis*) are managed under an annual permit from the U.S. Fish and Wildlife Services goose nest management program. Occasionally, nesting migratory birds come in conflict with ongoing or planned construction activities. When this occurs, the USDA-APHIS-Wildlife Services Division is called for consultation and resolution, if possible. Each incident is handled on a case-by-case basis to ensure the protection of migratory birds, while maintaining fiscal responsibility. See Chapter 6 for more information on migratory birds.

3.13.3 Bald and Golden Eagle Protection Act

While BNL does not have bald or golden eagles nesting on site, they do occasionally visit the area during migration. At times, immature golden eagles have spent several weeks in the area. Bald eagles are known to spend long periods of time on the north and south shores of Long Island, and the first documentation of nesting on the island occurred in 2013. Since that time, additional nesting pairs have been documented on Long Island. Currently, the Laboratory has no concerns with eagles and no specific management requirements have been identified. The growth of the bald eagle population on Long Island is being monitored and protections will be put in place, as necessary.

3.14 PUBLIC NOTIFICATION OF CLEARANCE OF PROPERTY

In accordance with DOE Order 458.1, authorized releases of property suspected of containing residual radioactive material must meet DOE and other federal, state, and local radiation protection policies and requirements. Released property must be appropriately surveyed, and the Laboratory must adequately demonstrate that authorized limits are met. In addition, documentation supporting the release of property should be publicly available. The release of property off the BNL site from radiological areas is controlled. No vehicles, equipment, structures, or other materials from these areas can be released from the Laboratory unless the amount of residual radioactivity on such items is less than the authorized limits. The default authorized limits are specified in the Brookhaven National Laboratory Site Radiological Control Manual (RCM) (BNL 2013b) and are consistent with the pre-approved authorized release limits set by DOE Order 458.1.

In 2014, excess materials such as scrap metal (256 tons) and electronics equipment (29 tons) were released to interested parties or to an off-site location. All materials were surveyed, as required, using appropriate calibrated instruments and released based on DOE pre-approved authorized limits. There were no releases of real property in 2014.

3.15 EXTERNAL AUDITS AND OVERSIGHT

3.15.1 Regulatory Agency Oversight

A number of federal, state, and local agencies oversee BNL activities. In addition to external audits and oversight, the Laboratory has a comprehensive self-assessment program, as described in Chapter 2. In 2014, BNL was inspected by federal, state, or local regulators on ten occasions. These inspections included:

- *Air Compliance.* BNL representatives accompanied NYSDEC on a site tour of Title V permitted facilities in December. No issues or areas of concern were identified.
- *Potable Water.* In October, SCDHS collected samples and conducted its annual inspection of the BNL potable water system. Corrective actions for all identified deficiencies

were established and communicated with SCDHS and are being addressed by the Laboratory's Energy and Utilities Division.

- *Sewage Treatment Plant.* SCDHS conducts quarterly inspections of the Laboratory's STP to evaluate operations and sample the effluent; no performance or operational issues were identified. NYSDEC performed an annual surveillance inspection in February; there were no issues identified.
- *Recharge Basins.* In December, SCDHS inspected several on-site SPDES-regulated outfalls and collected samples; there were no issues identified.
- *Major Petroleum Facility.* The annual NYSDEC inspection of the MPF was performed in April 2014. See Section 3.8.4 for a discussion of the issues identified.
- *Chemical Bulk Storage (CBS) Facilities.* The CBS facilities are inspected periodically by NYSDEC. An inspection was conducted in April 2014. See Section 3.8.5 for a discussion of the issues identified.
- *RCRA.* EPA performed a RCRA inspection in September 2014; there were no compliance issues reported.

3.15.2 DOE Assessments/Inspections

The DOE Brookhaven Site Office (BHSO) continued to provide oversight of BNL programs during 2014 and observed the programmatic assessment of BNL's Waste Management Program. The results of that assessment are summarized in the following section.

3.15.3 Environmental Multi-Topic Assessment

In 2014, BNL conducted a programmatic self-assessment on several aspects of the Laboratory's environmental management program. Topics for this assessment were determined based on institutional risk, DOE and regulatory agency expectations, and to ensure that key environmental requirements are being implemented as designed. The scope of the 2014 self-assessment focused on requirements related to BNL's waste management programs. The specific elements that were focused on during this assessment included compliance and conformance with hazardous, industrial, PCB,

regulated medical, mixed, and radioactive waste management. During the course of the assessment, a representative sampling of managers, supervisors, and workers were interviewed. In addition, numerous documents and activities were reviewed to enable a comprehensive, independent, and objective assessment of the conformance to requirements and the effectiveness of implementation.

The assessment of these programs identified four Noteworthy Practices, forty-five Minor Nonconformances, and one Opportunity for Improvement. Except for the noted Minor Nonconformances, the waste management program as a whole was found to be in conformance with applicable BNL Standards Based Management System and external regulatory requirements. A causal analysis was performed and corrective action plan prepared for the identified nonconformances to address the issues. Progress on the corrective actions was tracked to closure in BNL's Institutional Assessment Tracking System.

3.15.4 Nevada National Security Site

The Laboratory continues to be a certified Nevada National Security Site (NNSS) waste generator. As part of the NNSS waste certification process, the NNSS Maintenance and Operations Contractor conducts random unannounced inspections. NNSS performed a short notice surveillance of the Radioactive Waste Management Program in 2014. There were no non-conformances issued. One minor observation was noted on traceability of waste packages. The issue was corrected and closed with the assessment team's concurrence.

3.16 AGREEMENTS, ENFORCEMENT ACTIONS, AND OTHER ENVIRONMENTAL OCCURRENCE REPORTS

In addition to the rules and regulations discussed throughout this chapter, there were two existing agreements between BNL, DOE, and regulatory agencies that remained in effect in 2014 (Table 3-10). There were no Notices of Violation/Non-Compliance accessed in 2014; however, there was one environmental incident that required reporting through BNL's Occurrence Reporting and Processing System

(ORPS). The incident is summarized in Table 3-11. A causal analysis was performed and corrective actions were taken to prevent recurrence of this event.

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CHAPTER 3: COMPLIANCE STATUS

Table 3-10. Existing Agreements and Enforcement Actions Issued to BNL, with Status.

Number	Title	Parties	Effective Date	Status
Agreements				
No Number	Suffolk County Agreement	BNL, DOE, SCDHS	Originally signed on 09/23/87	This agreement was developed to ensure that the storage and handling of toxic and hazardous materials at BNL conform to the environmental and technical requirements of Suffolk County codes.
II-CERCLA-FFA-00201	Federal Facility Agreement under the CERCLA Section 120 (also known as the Interagency Agreement or "IAG" of the Environmental Restoration Program)	DOE, EPA, NYSDEC	05/26/92	This agreement provides the framework, including schedules, for assessing the extent of contamination and conducting cleanup at BNL. Work is performed either as an Operable Unit or a Removal Action. The IAG integrates the requirements of CERCLA, Resource Conservation and Recovery Act (RCRA), and the National Environmental Policy Act (NEPA). Cleanup is currently in long-term surveillance and maintenance mode for the groundwater treatment systems, former soil/sediment cleanup areas, and the reactors; this includes monitoring of institutional controls. The High Flux Beam Reactor (stack and reactor vessel are scheduled for decontamination and decommissioning by 2020 and 2072, respectively. All groundwater treatment systems operated as required in 2014.

No Notices of Violation/Enforcement Actions for 2014.

Notes:

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act

EPA = Environmental Protection Agency

NYSDEC = New York State Department of Environmental Conservation

SCDHS = Suffolk County Department of Health Services

Table 3-11. Summary of Other Environmental Occurrence Reports, 2014.

ORPS* ID: SC-BHSO-BNL-BNL-2014-0001	Date: 01/06/14
On January 6, 2014, Compressed Natural Gas (CNG) was simultaneously discharged from three pressure relief valves (PRVs) into the atmosphere at high pressure from the CNG Fueling Facility (Building 522). Fire Rescue personnel responded and assisted in isolating the area, de-energizing the gas compressor, closing the isolation valves upstream of the three PRVs, and closing the gas supply valve to the facility. BNL declared an Operational Emergency (OE) and activated the Emergency Operations Center (EOC). Impacted areas of the Laboratory were Sheltered-in-Place until it was confirmed that the natural gas had safely dissipated. It was estimated that between 700 to 1,000 lbs. of natural gas was released (far below the EPA reporting threshold of 10,000 lbs.). The facility was secured pending further investigation. No significant property damage was apparent and there were no injuries. The Alternate Laboratory Director for Facilities & Operations charged a team to investigate this event and determine the root and contributing causes, corrective actions, lessons learned, impact of the event, extent of condition, and OE response.	Status: Report is final; corrective actions have been identified and are being tracked to closure in BNL's Assessment Tracking System.

Notes:

* Reportable under the Occurrence Reporting and Processing System (ORPS), established by the requirements of DOE Order 231.1B Chg. 1, Environmental, Safety and Health Reporting.

Brookhaven National Laboratory monitors both radioactive and nonradioactive emissions at several facilities on site to ensure compliance with the requirements of the Clean Air Act. In addition, BNL conducts ambient air monitoring to verify local air quality and assess possible environmental impacts from Laboratory operations.

During 2014, BNL facilities released a total of 7,535 curies of short-lived radioactive gases. Oxygen-15 and carbon-11 emitted from the Brookhaven Linac Isotope Producer constituted more than 99.99 percent of the site's radiological air emissions.

Because natural gas prices were comparatively lower than residual fuel prices throughout the year, BNL's Central Steam Facility used natural gas to meet 99.3 percent of the heating and cooling needs of the Laboratory's major facilities in 2014. As a result, emissions of particulates, oxides of nitrogen, sulfur dioxide, and volatile organic compounds were well below the respective regulatory permit criteria pollutant limits.

4.1 RADIOLOGICAL EMISSIONS

Federal air quality laws and DOE regulations that govern the release of airborne radioactive material include 40 CFR 61 Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAPs)—part of the Clean Air Act (CAA), and DOE Order 458.1 Chg. 3, *Radiation Protection of the Public and the Environment*. Under NESHAPs Subpart H, facilities that have the potential to deliver an annual radiation dose of greater than 0.1 mrem (1 μ Sv) to a member of the public must be continuously monitored for emissions. Facilities capable of delivering radiation doses below that limit require periodic, confirmatory monitoring. BNL has one facility that is continuously monitored with an in-line detection system, the Brookhaven Linac Isotope Producer (BLIP). During 2014, periodic monitoring was conducted at one active facility, the Target Processing Laboratory (TPL), and one inactive facility, the High Flux Beam Reactor (HFBR). Figure 4-1 provides the locations of these monitored facilities, and Table 4-1 presents the airborne release data for each of these facilities. Annual emissions from monitored

facilities are discussed in the following sections of this chapter. The associated radiation dose estimates are presented in Chapter 8, Table 8-4.

4.1.1 High Flux Beam Reactor

In 1997, a plume of tritiated groundwater was traced back to a leak in the HFBR spent fuel storage pool. Consequently, the HFBR was put in standby mode until November 1999, when DOE declared that it was to be permanently shut down. Residual tritium in water in the reactor vessel and piping systems continued to diffuse into the building's air through valve seals and other system penetrations, though emission rates were much lower than during the years of operation.

In 2010, the HFBR was disconnected from the 100-meter stack, and a new HFBR exhaust system was installed in 2011. As part of the HFBR Long-Term Surveillance Program (BNL 2012) air samples are now collected from outside the HFBR confinement using a permanently installed sample port. Samples are analyzed for tritium to evaluate facility emissions and to ensure that air quality within the building is acceptable to permit staff entry. Additionally,

Figure 4-1. Air Emission Release Points Subject to Monitoring.

samples are collected one week per month from the HFBR exhaust system using a standard desiccant sampling system for tritium analysis. Desiccant samples are analyzed by an off-site contract laboratory.

4.1.2 Brookhaven Linac Isotope Producer

Protons from the Linear Accelerator (Linac) are sent via an underground beam tunnel to the BLIP, where they strike various metal targets to produce new radionuclides for medical diagnostics. The activated metal targets are transferred to the TPL in Building 801 for separation and shipment to various radiopharmaceutical research laboratories. During irradiation, the targets

become hot and are cooled by a continuously recirculating water system. The cooling water also becomes activated during the process, producing secondary radionuclides. The most significant of these radionuclides are oxygen-15 (O-15, half-life: 122 seconds) and carbon-11 (C-11, half-life: 20.4 minutes). Both of these isotopes are released as gaseous, airborne emissions through the facility's 33-foot stack. Emissions of these radionuclides are dependent on the current and energy of the proton beam used to manufacture the radioisotopes.

In 2014, BLIP operated over a period of 32 weeks, during which 2,511 Ci of C-11 and 5,023 Ci of O-15 were released. Tritium

produced from activation of the target cooling water was also released, but in a much smaller quantity, 3.25 E-2 Ci. Combined emissions of C-11 and O-15 were 7,534 Ci, 53 percent higher than the combined emission of 4,918 Ci in 2013. This increase is primarily due to operation at higher energy levels in 2014.

4.1.3 Target Processing Laboratory

As mentioned in Section 4.1.2, metal targets irradiated at the BLIP are transported to the TPL in Building 801, where isotopes are chemically extracted for radiopharmaceutical production. Airborne radionuclides released during the extraction process are drawn through multistage HEPA and charcoal filters and the filtered air is then vented to the atmosphere. The types of radionuclides that are processed depend on the isotopes chemically extracted from the irradiated metal targets, which may change from year to year. Annual radionuclide quantities released from this facility are very small, typically in the μCi to mCi range. Gamma analysis of monthly composite samples was discontinued in 2013. This decision was based on historical analytical results of TPL particulate filters that showed gross alpha/beta levels to be very low, and consistent with background concentrations. As a result, there are no reported radionuclide emissions from the TPL in Table 4-1. Should future gross beta analyses of TPL emissions show the potential for other radionuclide emissions, gamma analyses will be conducted.

4.1.4 Additional Minor Sources

Several research departments at BNL use designated fume hoods for work that involves small quantities of radioactive materials (in the μCi to mCi range). The work typically involves labeling chemical compounds and transferring material between containers. Due to the use of HEPA filters and activated charcoal filters, the nature of the work conducted, and the small quantities involved, these operations have a very low potential for atmospheric releases of significant quantities of radioactive materials. Compliance with NESHAPs Subpart H is demonstrated through the use of an inventory system that allows an upper estimate of potential releases to be calculated.

Table 4-1. Airborne Radionuclide Releases from Monitored Facilities.

Facility	Nuclide	Half-Life	Ci Released
HFBR	Tritium	12.3 years	4.87E-01
BLIP	Carbon-11	20.4 minutes	2.51E+03
	Oxygen-15	122 seconds	5.02E+03
	Tritium	12.3 years	3.25E-02
Total			7.535E+03

Notes:

Ci = $3.7\text{E}+10$ Bq

BLIP = Brookhaven Linac Isotope Producer

HFBR = High Flux Beam Reactor (operations were terminated in November 1999)

Facilities that demonstrate compliance in this way include Buildings 197, 197B, 463, 480, 490, 490A, 510A, 725, 801, 815, 865, and 901, where research is conducted in the fields of nuclear safety, biology, high energy physics, medicine, medical therapy, photon science, advanced technology, environmental chemistry, and synthetic biology. See Table 8-4 in Chapter 8 for the calculated dose from these facility emissions.

4.1.5 Nonpoint Radiological Emission Sources

Nonpoint radiological emissions from a variety of diffuse sources may be evaluated for compliance with NESHAPs Subpart H. Diffuse sources evaluated often include planned research, planned waste management activities, and planned D&D activities. In 2014, the only diffuse source evaluated was for planned soil remediation work at the Former Hazardous Waste Management Facility. The EPA-approved CAP88-PC dose modeling computer program was used to calculate the possible dose to members of the public from the planned activities. Evaluations determined whether NESHAPs permitting and continuous monitoring requirements are applicable, or whether periodic confirmatory sampling is needed to ensure compliance with Subpart H standards for radionuclide emissions. Chapter 8 discusses the NESHAPs evaluations of environmental restoration activities that occurred in 2014.

4.2 FACILITY MONITORING

Radioactive emissions are monitored at the TPL, BLIP, and HFBR. The samplers in the TPL exhaust duct and the exhaust stack for BLIP

are equipped with glass-fiber filters that capture samples of airborne particulate matter generated at these facilities (see Figure 4-1 for locations). The filters are collected and analyzed weekly for gross alpha and beta activity. Particulate filter analytical results for gross alpha and beta activity in 2014 are reported in Table 4-2. The average gross alpha and beta airborne activity levels for samples collected from the BLIP exhaust stack were 0.0003 and 0.0097 pCi/m³, respectively. Annual average gross alpha and beta airborne activity levels for samples collected from the TPL were 0.0007 and 0.0106 pCi/m³, respectively.

4.3 AMBIENT AIR MONITORING

As part of the Environmental Monitoring Program, air monitoring stations are in place around the perimeter of the BNL site (see Figure 4-2 for locations). There are six blockhouse stations and three pole-mounted, battery-powered silica-gel samplers equipped for collecting samples.

At each blockhouse, vacuum pumps draw air through columns where particulate matter is captured on a glass-fiber filter. Particulate filters are collected weekly, and are analyzed for gross alpha and beta activity using a gas-flow proportional counter. Also, water vapor for tritium analysis is collected on silica-gel absorbent material for processing by liquid scintillation analysis. In 2014, silica-gel samples were collected every two weeks.

4.3.1 Gross Alpha and Beta Airborne Activity

Particulate filter analytical results for gross alpha and beta airborne activity are reported in Table 4-3. Ambient air samples are collected weekly from site perimeter monitoring stations P2, P4, P7, and P9. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., sample air volumes were not acceptable). The annual average gross alpha and beta airborne activity levels for the four monitoring stations were 0.0016 and 0.0146 pCi/m³, respectively. Annual gross beta activity trends recorded at Station P7 are plotted in Figure 4-3. The results for this location are typical for the site, and show seasonal variation in activity within a range that is representative of natural background levels. The New York State Department

of Health (NYSDOH) received duplicate filter samples that were collected at Station P7, using a sampler they provided. These samples were collected weekly and analyzed by the NYSDOH laboratory for gross beta activity. The analytical results were comparable to the Station P7 samples analyzed by General Engineering Lab, an analytical laboratory contracted by BNL. New York State's analytical results for gross beta activity at the Laboratory were between 0.0021 and 0.0200 pCi/m³, with an average concentration of 0.0088 pCi/m³. BNL results ranged from 0.0035 to 0.0451 pCi/m³, with an average concentration of 0.0104 pCi/m³.

As part of a statewide monitoring program, NYSDOH also collects air samples in Albany, New York, a control location with no potential to be influenced by nuclear facility emissions. In 2014, NYSDOH reported that airborne gross beta activity at that location varied between 0.0007 and 0.1180 pCi/m³, and had an average concentration of 0.0133 pCi/m³. All of the sample results measured at BNL fell within this range, demonstrating that on-site radiological air quality was consistent with that observed at locations in New York State not located near radiological facilities.

4.3.2 Airborne Tritium

Airborne tritium in the form of HTO (tritiated water) is monitored throughout the BNL site. In addition to the five blockhouses containing tritium samplers, three pole-mounted monitors that may be used for tritium sampling are located at or near the Laboratory's property boundary (see Figure 4-2 for sample locations). Tritium sampling in 2014 was limited to Stations P2, P4, P7, and P9 on the basis that they are adequately located around the site's perimeter to monitor potential impacts from BNL's three tritium sources. Table 4-4 lists the number of validated samples collected at each location, the maximum value observed, and the annual average concentration. Validated samples are those not rejected due to equipment malfunction or other factors (e.g., a battery failure in the sampler, frozen or supersaturated silica gel, insufficient sample volumes, or the loss of sample during preparation at the contract analytical

Figure 4-2. BNL On-Site Ambient Air Monitoring Stations.

laboratory). Airborne tritium samples were collected every two weeks from each sampling station during 2014; however, 25 samples could not be analyzed because moisture captured on silica gel was insufficient for analysis. The average tritium concentrations at all of the sampling locations were less than the typical minimum detection limits (MDLs), which ranged from 1.3 to 6.2 pCi/m³.

4.4 NONRADIOLOGICAL AIRBORNE EMISSIONS

Various state and federal regulations governing nonradiological releases require facilities to

conduct periodic or continuous emission monitoring to demonstrate compliance with emission limits. The Central Steam Facility (CSF) is the only BNL facility that requires monitoring for nonradiological emissions. The Laboratory has several other emission sources subject to state and federal regulatory requirements that do not require emission monitoring (see Chapter 3 for more details). The CSF supplies steam for heating and cooling to major BNL facilities through an underground steam distribution and condensate grid. The location of the CSF is shown in Figure 4-1. The combustion units at the CSF are

Table 4-2. Gross Activity in Facility Air Particulate Filters.

Facility Monitor		Gross Alpha	Gross Beta
		(pCi/m ³)	
BLIP	N	51	51
	Max.	0.0022 ± 0.0010	0.1330 ± 0.0050
	Avg.	0.0003 ± 0.0004	0.0097 ± 0.0011
	MDL	0.0007*	0.0008*
TPL - Bldg. 801	N	51	51
	Max.	0.0029 ± 0.0007	0.0586 ± 0.0021
	Avg.	0.0007 ± 0.0004	0.0106 ± 0.0010
	MDL	0.0005*	0.0006*

Notes:

See Figure 4-2 for sample station locations.

All values shown with a 95% confidence interval.

BLIP = Brookhaven Linac Isotope Producer

MDL = minimum detection limit

N = Number of validated samples collected

TPL = Target Processing Laboratory

*Average MDL for all validated samples taken at this location

designated as Boilers 1A, 5, 6, and 7. Boiler 1A, which was installed in 1962, has a heat input of 16.4 MW (56.7 million British thermal units [MMBtu] per hour). Boiler 5, installed in 1965, has a heat input of 65.3 MW (225 MMBtu/hr). The newest units, Boilers 6 and 7, were installed in 1984 and 1996, and each has a heat input of 42.6 MW (147 MMBtu/hr). For perspective, National Grid's Northport, New York, power station has four utility-sized turbine/generator boilers, each with a maximum rated heat input of 1,082 MW (3,695 MMBtu/hr).

Because the CSF boilers have the potential to emit more than 100 tons per year of oxides of nitrogen (NO_x), the CSF is considered a major facility, and all four of its boilers are subject to the Reasonably Available Control Technology (RACT) requirements of Title 6 of the New York Code, Rules, and Regulations (NYCRR) Part 227-2. Because of their design, heat inputs, and dates of installation, Boilers 6 and 7 are also subject to the Federal New Source Performance Standard (40 CFR 60 Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Boilers). Both boilers are equipped with continuous emission monitoring systems (CEMS) to show compliance with NO_x standards of Part 227-2 and Subpart Db, and with continuous opacity monitors to demonstrate

Table 4-3. Gross Activity Detected in Ambient Air Monitoring Particulate Filters.

Sample Station		Gross Alpha	Gross Beta
		(pCi/m ³)	
P2	N	51	51
	Max	0.0031 ± 0.0008	0.0240 ± 0.0018
	Avg.	0.0015 ± 0.0005	0.0119 ± 0.0010
	MDL	0.0005*	0.0006*
P4	N	50	50
	Max	0.0068 ± 0.0034	0.0493 ± 0.0060
	Avg.	0.0025 ± 0.0011	0.0204 ± 0.0022
	MDL	0.0011*	0.0015*
P7	N	52	52
	Max	0.0088 ± 0.0021	0.0451 ± 0.0033
	Avg.	0.0011 ± 0.0005	0.0104 ± 0.0010
	MDL	0.0005*	0.0006*
P9	N	52	52
	Max	0.0034 ± 0.0012	0.0263 ± 0.0019
	Avg.	0.0015 ± 0.0007	0.0158 ± 0.0015
	MDL	0.0007*	0.0009*
Grand Average		0.0016 ± 0.0007	0.0146 ± 0.0014

Notes:

See Figure 4-3 for sample station locations.

All values shown with a 95% confidence interval.

MDL = minimum detection limit

N = Number of validated samples collected

*Average MDL for all validated samples taken at this location

compliance with Subpart Db opacity monitoring requirements. To measure combustion efficiency, the boilers are also monitored for carbon monoxide (CO). Continuous emission monitoring results from the two boilers are reported quarterly to EPA and the New York State Department of Environmental Conservation (NYSDEC).

On July 1, 2014, new Part 227-2 lower reasonable available control limits (RACT) for NO_x emissions became effective. The respective NO_x RACT emission limits of 0.20 lbs/MMBtu for the combustion of natural gas and 0.30 lbs/MMBtu for the combustion of No. 6 oil burned in the CSF three large boilers dropped to 0.15 lbs/MMBtu for both fuels. Meanwhile, the NO_x RACT emission limit for the CSF's one mid-size boiler (Boiler 1A) dropped from 0.30 lbs/MMBtu to 0.20 lbs/MMBtu.

From May 1 to September 15, the peak

Note: All values are presented with a 95 percent confidence interval.

Figure 4-3. Airborne Gross Beta Concentration Trend Recorded at Station P7.

ozone period, owners and operators of boilers equipped with CEMS demonstrate compliance with Part 227-2 NO_x RACT limits by calculating the 24-hour average emission rate from CEMS readings and comparing the value to the emission limit. During the remainder of the year, the calculated 30-day rolling average emission rate is used to establish compliance. Boilers not equipped with CEMS must demonstrate compliance with NO_x RACT limits via periodic emissions testing. Following the end of each calendar quarter, facilities with boilers equipped with CEMS must tabulate and summarize applicable emissions, monitoring, and operating parameter measurements recorded during the preceding three months. Measured opacity levels cannot exceed 20 percent opacity, except for one 6-minute period per hour of not more than 27 percent opacity.

Because past emissions testing and CEMS results when No. 6 oil was burned have shown that all four CSF boilers cannot meet the new lower NO_x RACT standards, BNL is using a system averaging plan to demonstrate compliance in quarterly reports submitted to NYSDEC. This is accomplished with a NO_x ledger, where NO_x emission rate credits accumulated during quarterly periods when natural gas is burned at levels below the NO_x RACT limits offset ledger debits that

occur when any of the four boilers burn oil. The ledger must show that the actual NO_x weighted average emission rate of operating boilers is less than the Part 227-2 permissible NO_x weighted average rate for the quarter. For the third and fourth calendar quarters of 2014, the respective actual weighted average emission rates for operating boilers were 0.087 and 0.090 lbs/MMBtu, while the respective permissible weighted average emissions rates were 0.121 and 0.150 lb/MMBtu.

On July 17, 2014, Boiler 6 exceeded the new NO_x RACT limit of 0.15 lbs/MMBtu with a 24-hour average emission rate of 0.21 lbs/MMBtu while firing No. 6 oil. The exceedance occurred after natural gas service was interrupted to the CSF to permit modifications of utility natural gas line services. Natural gas service to the CSF was restored later that day after service line modifications were completed. As noted in Chapter 3, this exceedance was documented in the quarterly Site-Wide Air Emissions and Monitoring Systems Performance Report submitted to NYSDEC. Despite the exceedance, the actual weighted average emission rate for operating boilers that day was 0.123 lbs/MMBtu, which was less than the permissible weighted average emissions rate of 0.150 lbs/MMBtu.

In 2014, there was one excess opacity measurement recorded by Boiler 6 on November 25

Table 4-4. Ambient Airborne Tritium Measurements in 2013.

Sample Station	Wind Sector	Validated Samples	Maximum —— (pCi/m ³) ——	Average
P2	NNW	24	16.5 ± 6.3	3.7 ± 3.7
P4	WSW	25	18.0 ± 6.4	3.4 ± 3.6
P7	ESE	7	10.1 ± 4.4	3.9 ± 2.6
P9	NE	21	17.4 ± 6.9	4.0 ± 3.9
Grand Average				3.7 ± 4.2

Notes:

See Figure 4-3 for station locations.

Wind sector is the downwind direction of the sample station from the High Flux Beam Reactor (HFBR) stack.

All values reported with a 95% confidence interval.

Typical minimum detection limit for tritium is between 2.0 and 10.0 pCi/m³.DOE Order 5400.5 Air Derived Concentration Guide is 100,000 pCi/m³.

during scheduled service work on the continuous opacity system, and five excess opacity measurements recorded by Boiler 7. Two of the Boiler 7 excess opacity readings that occurred on October 8 during boiler startup were due to unknown causes, while the two excess readings recorded on November 24 were the result of a blower motor failure. The final excess opacity reading occurred during startup of Boiler 7 after the blower motor was replaced on November 25. During quarterly quality assurance tests of the opacity monitors for Boilers 6 and 7, multiple 6-minute periods greater than 20 percent opacity were also recorded. As noted in Chapter 3, all of the excursions were documented in quarterly Site-Wide Air Emissions and Monitoring Systems Performance Reports submitted to NYSDEC. While there are no regulatory requirements to continuously monitor opacity for Boilers 1A and 5, surveillance monitoring of visible stack emissions is a condition of BNL's Title V operating permit. Daily observations of stack gases recorded by CSF personnel throughout the year showed no visible emissions on days when the boilers were operated.

To satisfy quality assurance requirements for the continuous emissions monitoring system of the Laboratory's Title V operating permit, a relative accuracy test audit (RATA) of the Boilers 6 and 7 continuous emissions monitoring systems for NO_x and CO₂ was conducted in December 2014. The results of the RATA demonstrated that the Boiler 6 and 7 NO_x and CO₂ continuous emissions monitoring systems met

RATA acceptance criteria, which are defined in 40 CFR 60, Appendix B, Specifications 2 and 3.

In 2014, residual fuel prices exceeded those of natural gas for most of the year. As a result, natural gas was used to supply more than 99.3 percent of the heating and cooling needs of BNL's major facilities. By comparison, in 2005, residual fuel satisfied 99.9 percent of the major facility heating and cooling needs. Consequently, 2014 emissions of particulates, NO_x, and sulfur dioxide (SO₂) were 12.6, 49.5, and 92.1 tons less than the respective totals for 2005, when No. 6 oil was the predominant fuel. All emissions were well below the respective permit limits of 113.3, 159, and 445 tons. Table 4-5 shows fuel use and emissions since 2005.

4.5 GREENHOUSE GAS EMISSIONS

One of the overarching goals of Executive Order (EO) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, is for federal agencies to establish agency-wide greenhouse gas (GHG) reduction targets for their combined Scope 1 and 2 greenhouse gas emissions and for their Scope 3 greenhouse gas emissions (see Appendix A for definitions). DOE has set the following GHG emission reduction goals for fiscal year 2020: reduce Scope 1 and 2 GHG emissions by 28 percent relative to their fiscal year (FY) 2008 baseline and reduce Scope 3 GHG emissions by 13 percent relative to their FY 2008 baseline.

BNL includes these same goals in its annual Site Sustainability Plan (SSP), which is submitted to DOE in December of each year (BNL 2014). Due to planned programmatic growth with the addition of the Laboratory's National Synchrotron Light Source II (NSLS-II) and other programs, Scope 1 and 2 emissions are projected to increase to 297,000 metric tons carbon dioxide equivalent (MtCO₂e) by 2020, a 44 percent increase from the FY 2008 baseline of 205,628 MtCO₂e. Due to the projected increase, meeting the Scope 1 and 2 reduction goal will be difficult. BNL's SSP identifies a number of actions that have or will be taken to help the Laboratory move towards this goal.

In November 2011, the Long Island Solar Farm (LISF), a large array of more than 164,000

Table 4-5. Central Steam Facility Fuel Use and Emissions (2005–2014).

Annual Fuel Use and Fuel Heating Values							Emissions			
Year	No. 6 Oil (10 ³ gals)	Heating Value (MMBtu)	No. 2 Oil (10 ³ gals)	Heating Value (MMBtu)	Natural Gas (10 ⁶ ft ³)	Heating Value (MMBtu)	TSP (tons)	NO _x (tons)	SO ₂ (tons)	VOCs (tons)
2005	4,206.12	618,590	0.87	122	0.00	0	15.2	80.4	93.1	2.4
2006	2,933.00	432,430	0.22	30	191.35	195,177	11.8	66.9	66.3	2.2
2007	2,542.85	374,432	0.00	0	263.04	268,301	9.7	77.3	59.3	2.2
2008	1,007.49	148,939	0.10	14	496.48	506,406	5.7	46.7	23.0	1.9
2009	1,904.32	283,734	0.00	0	375.03	382,529	9.0	53.4	44.9	2.1
2010	447.47	66,591	0.00	0	561.42	568,939	3.4	41.5	10.0	1.8
2011	31.49	4,726	0.01	2	657.06	668,564	2.6	30.4	0.9	1.8
2012	43.44	6,519	0.00	0	613.44	630,616	2.5	29.1	1.2	1.7
2013	117.21	17,590	0.00	0	631.95	649,645	2.9	30.7	2.9	1.8
2014	34.03	5,107	0.00	0	673.80	690,584	2.6	30.9	1.0	1.9
Permit Limit (in tons)							113.3	159.0	445.0	39.7

Notes:

NO_x = oxides of nitrogenSO₂ = sulfur dioxide

TSP = total suspended particulates

VOCs = volatile organic compounds

solar photovoltaic panels constructed on site began producing solar power. Annually, the LISF is expected to deliver 44 million kilowatt-hours of solar energy into the local utility grid. This equates to 28,000 MtCO₂e that the Laboratory can count on as GHG offsets or reductions. In March 2011, BNL began receiving 15 megawatts per hour of hydropower from the New York Power Authority. In 2014, BNL consumed 120,555 megawatts of hydropower, providing a net GHG reduction of 73,538 MtCO₂e.

In October 2013, DOE awarded a Utility Energy Service Contract. This project allows for the implementation of energy savings measures and is scheduled for completion by late 2015. In addition to energy savings, it will reduce Scope 1 and 2 GHG levels by approximately 7,000 MtCO₂e. By the end of 2014, BNL was nearly 50 % complete with Phase I energy conservation measures that included:

- Improvements that will increase the efficiency of supplying chilled water
- Upgraded lighting throughout the site
- Computerized building control upgrades and additions to provide for heating, ventilation, and air conditioning temperature setbacks

Other planned energy savings initiatives include improvements at the CSF and in the steam

distribution system, and the construction of a combined heat and power plant.

To meet the 2020 Scope 3 GHG emissions reduction goal, Scope 3 emissions must be lowered by 2,618 MtCO₂e from the FY 2008 baseline of 20,136 MtCO₂e. A secondary Scope 3 goal set by DOE is to reduce GHG emissions from employee business travel by 12 percent from the FY 2008 baseline or 1,056 MtCO₂e. Overall, Scope 3 GHG emissions have dropped by 2,735 MtCO₂e or 13.6 percent from FY 2008 to FY 2014, despite a 995 MtCO₂e or 2.2 percent increase in employee business travel GHG emissions over the same period. This reduction was a direct result of the purchase and use of 120,555 megawatt-hours of hydropower from the New York Power Authority in 2014. Hydropower purchased in 2014 accounted for 41.5 percent of all BNL power purchases. As a result, GHG emissions from transmission and distribution losses dropped 2,898 MtCO₂e, or 26.1 percent.

To achieve the employee travel reduction goal, BNL must reduce its employee travel GHGs by 1,056 MtCO₂e. Reaching this goal is complicated by a growing employee population that rose 5.2 percent from 2,669 full-time employees at the end of FY 2008 to 2,808 as of September

in 2014. Further increases are projected due to programmatic growth. Actions taken in 2014 and others planned in 2015 that will help BNL move forward in meeting the employee business travel GHG reduction goals included:

- BNL staff continued to work with administrators of MetroPool, the New York State Department of Transportation regional commuting services contractor, to review the scope of customized rideshare portal options intended to enhance employee interest and participation in ridesharing. After the meeting, BNL staff reconsidered planned rideshare website improvements, choosing instead to work with the Web Services Group to convert the current rideshare website to a Commuter Choice website. The new website will stress both the environmental and work/life balance benefits of more sustainable commuting options, as well as the resources available to enable employees to rideshare, commute by bicycle, use mass transit, and establish compressed work or telework schedules. BNL Environmental Protection Division staff subsequently met with the Web Services Group to review the current rideshare website and to discuss desired elements for the new Commuter Choice website.
- A working group led by BNL Human Resources developed two new procedures that will be added to the the Laboratory's Standards-Based Management System (SBMS) Flexible Work Arrangements Subject Area. These new procedures expand flexible work-week and compressed workweek schedules for non-bargaining non-exempt employees and non-bargaining employees, respectively.
- BNL's Badging Office amended forms used to register employee vehicles and provide stickers for site entrance purposes. The form now includes the vehicle model, in addition to the model year and make that was previously recorded. These records will serve as an improved metric for estimating the average mileage of vehicles used in vehicle commuting and for measuring reductions in commuter GHG emissions over time as

employees replace older less fuel efficient models with vehicles meeting the progressively higher corporate average fuel economy standards that became effective with 2011 model year light duty vehicles.

Future actions that should help to reduce business travel GHG emissions include plans to expand user teleconferencing capabilities through the deployment of enhanced communications technologies in FY 2015 as part of BNL's site-wide telephone replacement project. In addition to providing users with the ability to rapidly schedule and conduct ad-hoc audio teleconferences, the new technologies will enable users to integrate desktop video teleconferencing capabilities with larger room-based sessions and mobile devices. This allows teleconferencing sessions to be scheduled by any individual user, and spans the use of previously disparate technologies. As such, the need to travel for traditional face-to-face meetings is expected to decrease.

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Water Quality

5

Wastewater generated from operations at Brookhaven National Laboratory is discharged to surface waters via the Sewage Treatment Plant (STP) and to groundwater via recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and vigilant operation of treatment facilities ensure that these discharges comply with all applicable regulatory requirements and that the public, employees, and the environment are protected. In October 2014, STP discharge to the Peconic River ceased after construction of a new final filtration system and groundwater recharge basins.

Analytical data for 2014 show that the average gross alpha and beta activity levels in the STP discharge (EA, Outfall 001) were within the typical range of historical levels and were well below New York State Drinking Water Standards (NYS DWS). Tritium was not detected above method detection limits in the STP discharge during the entire year and no cesium-137, strontium-90, or other gamma-emitting nuclides attributable to Laboratory operations were detected. Nonradiological monitoring of the STP effluent showed that organic and inorganic parameters were within State Pollutant Discharge Elimination System (SPDES) effluent limitations or other applicable standards.

The average concentrations of gross alpha and beta activity in water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected in 2014. Tritium was not detected above method detection limits in any of the discharges to recharge basins. Disinfection byproducts continue to be detected at very low concentrations, just above the method detection limit, in discharges to recharge basins due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics (i.e., metals) were detected; however, their presence is due primarily to sediment run-off in stormwater discharges.

Radiological data from Peconic River surface water sampling in 2014 show that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from off-site locations and control locations, and all detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the STP, and tritium was not detected above method detection limits in any of the surface water samples. Inorganic data from Peconic River samples collected upstream, downstream and at control locations demonstrated that elevated amounts of aluminum and iron detected in the river are associated with natural sources. Concentrations of silver, copper, lead, and zinc detected were consistent with concentrations found in the STP discharge, and were within BNL SPDES permit limits.

5.1 SURFACE WATER MONITORING PROGRAM

Treated wastewater from the Laboratory's STP was discharged into the headwaters of the

Peconic River between January 1 and September 30, 2014. Starting in October 2014, discharges to the river ceased after construction of

a new final filtration system and groundwater recharge basins. Both discharges were permitted under the New York State Department of Environmental Conservation (NYSDEC) SPDES Program. Effluent limits are based on water quality standards established by NYSDEC, as well as historic operational data. To assess the impact of wastewater discharge on Peconic River water quality, surface water is monitored at several locations upstream and downstream of the discharge point. On-site Monitoring Station HY is located upstream of all Laboratory operations, and provides information on the background water quality of the Peconic River (see Figure 5-4). The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL and is not within the Peconic River watershed.

On the Laboratory site, the Peconic River is an intermittent, groundwater fed stream. Off-site flow occurs only following periods of sustained precipitation and a concurrent rise in the water table, typically in the spring. Off-site flow in 2014 was only persistent between March and April due to a wet spring. When flow ceased, standing water was present throughout the year in several of the deeper sections of the river.

Five years of analytical data associated with BNL's surface water monitoring program were evaluated in 2012, and a determination was made to reduce the sampling frequencies for both on- and off-site Peconic River monitoring stations starting in 2013. This decision was based on the fact that historical monitoring data indicates no significant variations in water quality throughout the Peconic River system, Peconic River remediation efforts have been completed, and pollution prevention efforts at the Laboratory have significantly reduced the risk of accidental releases to the sanitary system. This decision is further supported by the October 2014 redirection of STP discharges away from the Peconic River. The following sections describe BNL's surface water monitoring and surveillance program.

5.2 SANITARY SYSTEM EFFLUENTS

The STP effluent (Outfall 001) is a discharge

point authorized under BNL's SPDES permit. Figure 5-1a shows a schematic of the STP and its sampling locations when discharge was to the Peconic River. Figure 5-1b shows a schematic for discharge to groundwater via the newly constructed recharge basins. The Laboratory's STP treatment process (starting in October 2014) includes three principal steps: 1) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 2) secondary clarification, and 3) filtration for final solids removal. Tertiary treatment for nitrogen removal is also provided by controlling the oxygen levels in the aeration tanks. During the aeration process, the oxygen levels are allowed to drop to the point where microorganisms use nitrate-bound oxygen for respiration; this liberates nitrogen gas and consequently reduces the concentration of nitrogen in the STP discharge.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity occurs at two locations. The first site, MH-192 (see Figure 5-1a), is approximately 1.1 miles upstream of the STP, and provides a minimum of 30 minutes' warning to the STP operators that wastewater is en route that may exceed SPDES limits or BNL administrative effluent release criteria. The second monitoring site is at the point where the STP influent enters the treatment process.

Based on the data collected by the real-time monitoring systems, any influent to the STP that may not meet SPDES limits and BNL effluent release criteria can be diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds 6 million gallons, or approximately 18 days of flow. Diversion would continue until the effluent's water quality meets the permit limits and release criteria. If wastewater is diverted to the holding ponds, it is tested and evaluated against the requirements for release. If necessary, the wastewater is treated and then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for nonradiological parameters or BNL effluent release criteria for radiological parameters. In 2014, there were no instances that required diversion of wastewater to the hold-up ponds.

Figure 5-1a. Schematic of BNL's Sewage Treatment Plant (Peconic River Discharge)

Figure 5-1b. Schematic of BNL's Sewage Treatment Plant (Recharge Basin Discharge)

Solids separated in the clarifier are pumped to aerobic digesters for continued biological solids reduction and sludge thickening. Once the sludge in the aerobic digester reaches a solids content of 6 percent, the sludge is sampled to

ensure it meets the waste acceptance criteria for disposal at the Suffolk County Department of Public Works Sewage Treatment Facility at Bergen Point, in West Babylon, New York.

5.2.1 Sanitary System Effluent–Radiological Analyses

Wastewater at the STP is sampled at the inlet to the treatment process, Station DA (see Figure 5-1a) and at the STP outfall Station EA. At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons of water treated, approximately 4 fluid ounces of sample are collected and composited into a 5-gallon collection container. These samples are analyzed for gross alpha and gross beta activity and for tritium. In 2014, samples were collected weekly. In previous years, samples were collected three times per week. The reduction in sampling frequency was justified after a review of radiological data collected over the previous five years showed only an occasional low-level detection of tritium and no detection of any other BNL-generated radionuclides in both the STP influent and effluent. In addition, the sewage collection system is monitored in real-time using beta and gamma detection systems to detect any unplanned releases that could jeopardize the quality of the STP effluent. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90 (Sr-90: half-life, 29 years).

Although the STP discharge is not used as a direct source of potable water, the Laboratory applies the stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of DOE wastewater criteria. Under the SDWA, water standards are based on a 4 mrem (40 μ Sv) dose limit. The SDWA specifies that no individual may receive an annual dose greater than 4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. BNL performs radionuclide-specific gamma analysis to ensure compliance with this standard. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 (Ra-226: half-life, 1,600 years), but excluding radon and uranium. Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium (H-3: half-life, 12.3 years), 8 pCi/L for Sr-90, 5 pCi/L for Ra-226 and radium-228 (Ra-228: half-life, 5.75 years), and 30 μ g/L for

uranium. Gross alpha and beta activity measurements are used as a screening tool for detecting the presence of radioactivity. Table 5-1 shows the monthly gross alpha and beta activity data and tritium concentrations for the STP influent and effluent during 2014. Annual average gross alpha and beta activity levels in the STP effluent were 0.4 ± 0.2 pCi/L and 4.4 ± 0.4 pCi/L, respectively. These concentrations have remained essentially unchanged from year to year. The average concentrations of gross alpha and beta activity in Peconic River samples collected upstream of BNL were 0.62 ± 0.66 pCi/L and 0.9 ± 1.1 pCi/L, respectively. Tritium was not detected above method detection limits in the discharge of the STP (EA, Outfall 001) for the entire year. The annual average tritium concentration, as measured in the STP effluent, was 63.7 pCi/L, which is only 16 percent of the average minimum detection level (MDL) of 396 pCi/L, and well below the NYS DWS of 20,000 pCi/L. Using the annual average concentration and the flow recorded for the year, a total of 0.025 Ci (25 mCi) of tritium was released during 2014, which is consistent with total releases of tritium over the past five years. In 2014, there were no gamma-emitting nuclides detected in the STP effluent, which is consistent with data reported since 2003. Sr-90 was detected in one effluent sample collected in June (0.44 ± 0.27 pCi/L); however, this value is consistent with historical levels both upstream and downstream of the STP and most likely attributable to worldwide fallout and not BNL-derived.

5.2.2 Sanitary System Effluent – Nonradiological Analyses

Starting in 2013, surveillance monitoring of the STP for VOCs, inorganics, and anions was discontinued. This decision was based on historical data and that all of these parameters are already monitored as part of the Compliance Program, which is discussed in further detail in Chapter 3.

5.3 PROCESS-SPECIFIC WASTEWATER

Wastewater that may contain constituents above SPDES permit limits or ambient water quality discharge standards must be held by the generating facility and characterized to

Table 5-1. Tritium and Gross Activity in Water at the BNL Sewage Treatment Plant (STP).

		Flow (a) (Liters)	Tritium (pCi/L)		Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
			max.	avg.	max.	avg.	max.	avg.
January	influent	2.77E+07	< 412	<MDL	< 1.7	0.3 ± 0.6	4.0 ± 1.0	3.2 ± 1.1
	effluent	1.94E+07	< 422	<MDL	< 1.4	0.7 ± 0.4	4.4 ± 1.0	3.3 ± 0.8
February	influent	2.43E+07	< 378	<MDL	< 8.2	1.1 ± 0.5	4.5 ± 0.7	3.2 ± 1.2
	effluent	2.25E+07	< 412	<MDL	< 3.1	0.6 ± 0.8	6.2 ± 1.1	4.2 ± 1.4
March	influent	3.05E+07	< 481	<MDL	1.9 ± 2.0	1.4 ± 0.4	6.0 ± 1.6	4.8 ± 1.0
	effluent	3.24E+07	< 481	<MDL	< 1.3	0.0 ± 0.7	5.0 ± 1.2	3.8 ± 0.9
April	influent	3.00E+07	< 345	<MDL	< 3.6	1.5 ± 1.5	5.6 ± 1.4	5.1 ± 0.4
	effluent	3.09E+07	< 400	<MDL	< 2.0	0.2 ± 0.8	4.9 ± 1.0	3.8 ± 0.7
May	influent	4.14E+07	< 357	<MDL	< 2.9	1.6 ± 0.7	6.0 ± 1.9	5.1 ± 1.4
	effluent	3.38E+07	< 367	<MDL	1.2 ± 0.9	0.5 ± 0.9	6.4 ± 1.0	5.0 ± 1.0
June	influent	6.02E+07	< 440	<MDL	< 2.1	0.6 ± 0.6	6.5 ± 1.2	4.5 ± 1.3
	effluent	4.27E+07	< 443	<MDL	< 2.0	0.1 ± 0.4	5.5 ± 1.1	4.9 ± 0.4
July	influent	5.12E+07	< 399	<MDL	3.6 ± 2.5	1.3 ± 1.7	6.1 ± 1.7	4.3 ± 1.3
	effluent	4.11E+07	< 442	<MDL	< 2.5	0.2 ± 0.4	4.3 ± 1.1	3.9 ± 0.6
August	influent	4.88E+07	< 328	<MDL	< 1.4	0.0 ± 1.0	5.0 ± 1.5	4.1 ± 0.7
	effluent	3.36E+07	< 327	<MDL	< 2.5	0.7 ± 0.3	4.9 ± 1.1	4.2 ± 0.8
September	influent	9.79E+07	< 452	<MDL	2.1 ± 1.4	1.1 ± 0.7	7.3 ± 1.4	5.6 ± 1.4
	effluent	7.14E+07	< 377	<MDL	1.5 ± 0.9	0.5 ± 0.6	9.3 ± 1.4	6.9 ± 1.4
October	influent	3.61E+07	< 342	<MDL	< 2.7	1.5 ± 0.6	5.9 ± 0.9	4.9 ± 0.7
	effluent	2.45E+07	< 390	<MDL	< 2.0	0.1 ± 0.1	5.6 ± 1.2	4.8 ± 0.7
November	influent	3.27E+07	< 405	<MDL	< 2.4	0.9 ± 0.8	5.9 ± 1.2	4.0 ± 1.6
	effluent	2.49E+07	< 412	<MDL	< 1.4	0.5 ± 0.4	5.3 ± 0.9	4.9 ± 0.3
December	influent	4.07E+07	366 ± 223	<MDL	2.1 ± 1.1	0.7 ± 0.8	4.2 ± 0.8	3.7 ± 0.3
	effluent	3.24E+07	< 331	<MDL	< 1.8	0.4 ± 0.6	4.3 ± 1.0	3.2 ± 0.6
Annual Avg.	influent			<MDL		1.0 ± 0.3		4.4 ± 0.3
	effluent			<MDL		0.4 ± 0.2		4.4 ± 0.4
Total Release		4.10E+08		25 mCi		0.1 mCi		1.7 mCi
Average MDL (pCi/L)				396		1.6		0.9
SDWA Limit (pCi/L)				20,000		15		(b)

Notes:

All values are reported with a 95% confidence interval.

Negative numbers occur when the measured value is lower than background (see Appendix B for description).

To convert values from pCi to Bq, divide by 27.03.

(a) Effluent values greater than influent values occur when water diverted to the holding ponds is tested, treated (if necessary), and released.

(b) The drinking water standards were changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

MDL = minimum detection limit

SDWA = Safe Drinking Water Act

determine the appropriate means of disposal. The analytical results are compared with the appropriate discharge limit, and the wastewater is released to the sanitary system if the volume

and concentration of contaminants in the discharge would not jeopardize the quality of the STP effluent and, subsequently, the Peconic River and groundwater (BNL 2011).

The Laboratory's SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from printed-circuit-board fabrication operations conducted in Building 535B, metal cleaning operations in Building 498, and cooling tower discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). In 2014, analyses of these waste streams showed that, although several operations contributed contaminants (principally metals) to the STP influent in concentrations exceeding SPDES-permitted levels, these discharges did not affect the quality of the STP effluent.

Process wastewaters that were not expected to be of consistent quality, because they were not routinely generated, were held for characterization before release to the sanitary system. The process wastewaters typically included purge water from groundwater sampling, wastewater from cleaning of heat exchangers, wastewater generated as a result of restoration activities, and other industrial wastewaters. To determine the appropriate disposal method, samples were analyzed for contaminants specific to the process. The analyses were then reviewed and the concentrations were compared to the SPDES effluent limits and BNL's effluent release criteria. If the concentrations were within limits, authorization for sewer system discharge was granted; if not, alternate means of disposal were used. Any waste that contained elevated levels of hazardous or radiological contaminants in concentrations that exceeded BNL effluent release criteria was sent to the Laboratory Waste Management Facility for proper management and off-site disposal.

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of "clean" wastewater streams, including once-through cooling water, stormwater runoff, and cooling tower blowdown. With the exception of elevated temperature and increased natural sediment content, these wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-2 shows the locations of the Laboratory's

discharges to recharge basins (also called "out-falls" under BNL's SPDES permit). Figure 5-3 presents an overall schematic of potable water use at the Laboratory. Eleven recharge basins are used for managing once-through cooling water, cooling tower blowdown, and stormwater runoff:

- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS) and Relativistic Heavy Ion Collider (RHIC), as well as cooling tower blowdown and stormwater runoff.
- Basin HS receives predominantly stormwater runoff, once-through cooling water from Building 555 (Chemistry Department) and minimal cooling tower blowdown from the National Synchrotron Light Source (NSLS).
- Basin HX receives Water Treatment Plant filter backwash water.
- Basin HO receives cooling water discharges from the AGS and stormwater runoff from the area surrounding the High Flux Beam Reactor (HFBR).
- Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW near the National Synchrotron Light Source II (NSLS-II) site, Basin CSF at the Central Steam Facility (CSF), Basin HW-M at the Former Hazardous Waste Management Facility (FHWMF), and Basin HZ near Building 902. Recharge Basins HP and RAV are used for discharge of treated water from the groundwater remediation systems and are monitored under BNL's CERCLA equivalency permits.

Each of the recharge basins is a permitted point-source discharge under the Laboratory's SPDES permit. Where required by the permit, the discharge to the basin is equipped with a flow monitoring station; weekly recordings of flow are collected, along with measurements of pH. The specifics of the SPDES compliance monitoring program are provided in Chapter 3. To supplement the monitoring program, samples are also routinely collected and analyzed under BNL's Environmental Surveillance Program for radioactivity, VOCs, metals, and anions. During 2014, water samples were collected from all the basins listed above semi-annually except

Figure 5-2. BNL Recharge Basin/Outfall Locations.

recharge Basin HX at the Water Treatment Plant (exempted by NYSDEC from sampling due to documented non-impact to groundwater) and the recharge basin at the FHWMF, as there are no longer any operations that could lead to the contamination of runoff.

5.4.1 Recharge Basins – Radiological Analyses

Discharges to the recharge basins were sampled semi-annually and analyzed for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. The results are presented in Table 5-2, and show that low levels of alpha and beta activity were detected in most of the samples. Activities ranged from non-detectable

to 9.9 ± 5.1 pCi/L for gross alpha activity, and from non-detectable to 3.9 ± 1.1 pCi/L for gross beta activity. These low-level detections of gross alpha and beta activity are attributable to very low levels of naturally occurring radionuclides, such as potassium-40 (K-40: half-life, $1.3E+09$ years).

No gamma-emitting nuclides attributable to BNL operations were detected in any discharges, and tritium was not detected above method detection limits.

5.4.2 Recharge Basins – Nonradiological Analyses

To determine the overall impact on the environment from discharges to the recharge basins,

the nonradiological analytical results were compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations (NYCRR), Part 703.6. Samples were collected semi-annually for water quality parameters, metals, and VOCs. Field-measured parameters (pH, conductivity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-3 and 5-4.

Low concentrations of disinfection byproducts were periodically detected above method detection limits in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, lead to the formation of VOCs, including bromoform, chloroform, dibromochloromethane, and dichlorobromomethane. All concentrations were less than 6 µg/L. Methylene chloride was detected just above the MDL in Basin HW in February and May 2014 (2.5 µg/L and 2.2 µg/L, respectively) and is attributed to cross-contamination within the contract laboratory. No other VOCs were detected above method detection limits in any of the recharge basins in 2014.

The analytical data in Table 5-3 show that for 2014, the concentrations of all analytes were within effluent standards, except for high detections of chlorides in Basins HT-E, HW, and CSF. Chlorides are found to be higher in samples collected during the winter and are attributed to road salt used to control snow and ice buildup. These particular samples from Basins HT-E, HW, and CSF were collected in February during a rain event, which likely washed out a buildup of road salt in these areas that had been left over from previous snow events. High concentrations of sodium confirm road salt as the source of chlorides. The data in Table 5-4 show that all metals complied with the respective water quality or groundwater discharge standards.

5.4.3 Stormwater Assessment

All recharge basins receive stormwater runoff. Stormwater at BNL is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and

Table 5-2. Radiological Analysis of Samples from BNL On-Site Recharge Basins.

Basin		Gross Alpha	Gross Beta	Tritium
		(pCi/L)		
No. of samples		2	2	2
HN	max.	1.37 ± 0.96	1.28 ± 0.63	< 469
	avg.	0.96 ± 0.8	1.26 ± 0.04	<MDL
HO	max.	< 1.4	1.05 ± 0.62	< 407
	avg.	0.06 ± 0.46	0.86 ± 0.37	<MDL
HS	max.	< 2.6	3.95 ± 1.06	< 455
	avg.	-0.21 ± 0.3	3.71 ± 0.47	<MDL
HT-E	max.	< 1.35	< 39.4 (b)	< 457
	avg.	-6.65 ± 12.05	3.88 ± 6.46	<MDL
HT-W	max.	< 1.67	1.32 ± 0.6	< 462
	avg.	0.06 ± 0.04	1.06 ± 0.52	<MDL
HW	max.	9.96 ± 5.09	1.53 ± 0.64	< 340
	avg.	4.89 ± 9.93	-0.23 ± 3.45	<MDL
HZ	max.	< 1.54	< 1.01	< 416
	avg.	0.31 ± 0.26	0.63 ± 0.51	<MDL
SDWA Limit		15	(a)	20,000

Notes:

See Figure 5-2 for the locations of recharge basins/outfalls.

All values reported with a 95% confidence interval.

To convert values from pCi to Bq, divide by 27.03.

(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent of this value cannot be calculated.

(b) Due to high solids content, the minimum detection limit for this sample was very high.

MDL = Minimum Detection Limit

SDWA = Safe Drinking Water Act

above-grade vegetated swales. Recharge Basin HS receives most of the stormwater runoff from the central, developed portion of the Laboratory site. Basins HN, HZ, HT-W, and HT-E receive runoff from the Collider–Accelerator complex. Basin HO receives runoff from the Brookhaven Graphite Research Reactor (BGRR) and HFBR areas. Basin CSF receives runoff from the CSF area and along Cornell Avenue east of Renaissance Road. Basin HW receives runoff from the NSLS-II site, and HW-M receives runoff from the fenced area at the FHWMF.

Stormwater runoff at the Laboratory typically has elevated levels of inorganics and has low

Figure 5-3. Schematic of Potable Water Use and Flow at BNL.

pH. The inorganics are attributable to high sediment content in stormwater (inorganics occur naturally in native soil). In an effort to further improve the quality of stormwater runoff, BNL has formal procedures for managing and maintaining outdoor work and storage areas. The requirements include covering areas (e.g., tarps) to prevent contact with stormwater, conducting an aggressive maintenance and inspection program, implementing erosion control measures during soil disturbance activities, and restoring these areas when operations cease. Basin sediment sampling is conducted on a five-year testing cycle to ensure these discharges are in compliance with regulatory requirements. The next sampling event will occur in 2017.

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and to assess any impact from BNL discharges. Sampling points along the Peconic River are identified in Figure 5-4. In total, 10 stations (three upstream and seven downstream

of the STP) were sampled in 2014. A sampling station along the Carmans River (HH) was also monitored as a geographic control location, not affected by Laboratory operations or within the Peconic River watershed. All locations were monitored for radiological and nonradiological parameters.

As mentioned in Section 5.1, five years of analytical data associated with BNL's surface water monitoring program were evaluated in 2012, and a determination was made to reduce the sampling frequencies for both on- and off-site Peconic River monitoring stations starting in 2013. The sampling stations are located as follows:

Upstream sampling stations

- HY, on site, immediately east of the William Floyd Parkway
- HV, on site, just east of the 10:00 o'clock experimental hall in the RHIC Ring
- HE, on site, approximately 20 feet upstream of the STP outfall (EA)

Downstream sampling stations

- HM-N, on site, 0.5 mile downstream of the STP outfall

Table 5-3. Water Quality Data for BNL On-Site Recharge Basin Samples.

ANALYTE	Recharge Basin									NYSDEC Effluent Standard	Typical MDL
		HN (RHIC)	HO (AGS)	HS (s)	HT-W (Linac)	HT-E (AGS)	HW (s)	CSF (s)	HZ (s)		
No. of samples		2	2	2	2	2	2	2	2		
pH (SU)	min.	7.8	7.1	7.6	7.6	7.0	7.2	7.3	7.2	6.5 - 9.0	NA
	max.	8.2	7.5	8.0	7.9	8.6	7.7	7.8	7.4		
Conductivity (μS/cm)	min.	259	20	423	260	150	256	129	392	SNS	NA
	max.	529	156	769	307	975	2224	3634	481		
	avg.	394	88	596	284	563	1240	1882	437		
Temperature (°C)	min.	11.4	13.4	7.7	5.1	4.1	3.3	1.8	10.7	SNS	NA
	max.	22.1	21.4	23.8	22.9	7.0	21.7	21.8	23.2		
	avg.	16.8	17.4	15.8	14.0	5.5	12.5	11.8	17.0		
Dissolved oxygen (mg/L)	min.	8.4	8.7	9.6	7.7	9.2	8.9	8.6	8.0	SNS	NA
	max.	11.9	10.5	13.7	13.4	13.3	15.4	16.1	11.3		
	avg.	10.2	9.6	11.7	10.5	11.3	12.2	12.4	9.6		
Chlorides (mg/L)	min.	43.0	44.0	120.0	64.0	43.0	50.0	14.0	47.0	500	4
	max.	110.0	47.0	170.0	83.0	6400.0	620.0	970.0	110.0		
	avg.	76.5	45.5	145.0	73.5	3221.5	335.0	492.0	78.5		
Sulfates (mg/L)	min.	9.7	9.6	17.0	11.0	8.0	7.2	4.9	6.7	500	4
	max.	13.0	9.8	18.0	15.0	28.0	19.0	43.0	10.0		
	avg.	11.4	9.7	17.5	13.0	18.0	13.1	24.0	8.4		
Nitrate as nitrogen (mg/L)	min.	0.4	0.3	1.5	0.6	0.3	0.1	0.1	0.2	10	1
	max.	0.5	0.3	1.8	0.6	0.3	0.5	0.2	0.3		
	avg.	0.4	0.3	1.7	0.6	0.3	0.3	0.1	0.3		

Notes:

See Figure 5-2 for the locations of recharge basins/outfalls.

(s) = stormwater

AGS = Alternating Gradient Synchrotron

Linac = Linear Accelerator

MDL = Minimum Detection Limit

NA = Not Applicable

NYSDEC = New York State Department of Environmental Conservation

RHIC = Relativistic Heavy Ion Collider

SNS = Effluent Standard Not Specified

- HM-S, on site, on a typically dry tributary of the Peconic River
- HQ, on site, 1.2 miles downstream of the STP outfall at the site boundary
- HA, first station downstream of the BNL boundary, 3.1 miles from the STP outfall
- Donahue's Pond, off site, 4.3 miles downstream of the STP outfall
- Forge Pond, off site
- Swan Pond, off site, not within the influence of BNL discharges
- Control location
- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

Radionuclide measurements were performed on surface water samples collected from the Peconic River at all 10 sampling locations, plus the control location. Samples were collected at stations HM-N and HQ once per quarter, as flow allowed. All other stations were sampled semi-annually unless conditions (such as no water flow) prevented collection. Stations HE, HM-N, and HQ are equipped with Parshall flumes that allow automated flow-proportional sampling and volume measurements. All other sites were sampled by collecting instantaneous grab

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge Basins.

METAL		HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F		
No. of samples		2	2	2	2	2	2	2	2		
Ag Silver (µg/L)	min.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Al Aluminum (µg/L)	min.	< 50.0	< 50.0	71.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	2000	50
	max.	170.0	< 50.0	88.0	< 50.0	100.0	< 50.0	< 50.0	< 50.0		
	avg.	85.0	< 50.0	79.5	< 50.0	50.0	< 50.0	< 50.0	< 50.0		
As Arsenic (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	50	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	min.	28.0	28.0	28.0	30.0	37.0	37.0	26.0	26.0	2000	20.0
	max.	42.0	42.0	110.0	110.0	38.0	48.0	32.0	33.0		
	avg.	35.0	35.0	69.0	70.0	37.5	42.5	29.0	29.5		
Be Beryllium (µg/L)	min.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	SNS	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd Cadmium (µg/L)	min.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	10	2.0
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co Cobalt (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr Chromium (µg/L)	min.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	100	10.0
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Cu Copper (µg/L)	min.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	400	10.0
	max.	< 10.0	< 10.0	16.0	< 10.0	12.0	< 10.0	19.0	13.0		
	avg.	< 10.0	< 10.0	12.9	< 10.0	< 10.0	< 10.0	12.2	< 10.0		
Fe Iron (mg/L)	min.	< 0.05	< 0.05	0.30	0.09	0.05	0.05	< 0.05	< 0.05	0.6	0.05
	max.	0.10	< 0.05	0.42	0.20	0.08	< 0.05	0.13	0.05		
	avg.	0.06	< 0.05	0.36	0.15	0.06	< 0.05	0.09	< 0.05		
Hg Mercury (µg/L)	min.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1.4	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	min.	2.9	2.1	30.0	11.0	6.0	7.5	2.4	3.6	600	2.0
	max.	4.8	2.3	76.0	77.0	9.9	8.3	5.2	3.9		
	avg.	3.9	2.2	53.0	44.0	8.0	7.9	3.8	3.8		

(continued on next page)

Table 5-4. Metals Analysis of Water Samples from BNL On-Site Recharge Basins (concluded).

METAL		HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F		
No. of samples		2	2	2	2	2	2	2	2		
Na Sodium (mg/L)	min.	29.0	29.0	37.0	44.0	39.0	45.0	35.0	36.0	SNS	0.25
	max.	35.0	35.0	3400.0	3400.0	45.0	52.0	71.0	70.0		
	avg.	32.0	32.0	1718.5	1722.0	42.0	48.5	53.0	53.0		
Ni Nickel (µg/L)	min.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	200	10.0
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Pb Lead (µg/L)	min.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	50	3.0
	max.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	9.7	5.3		
	avg.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	5.4	3.0		
Sb Antimony (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	6	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se Selenium (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	20	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Tl Thallium (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5.0
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
V Vanadium (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5.0
	max.	< 5.0	< 5.0	< 5.0	5.2	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Zn Zinc (µg/L)	min.	< 10.0	10.0	27.0	20.0	13.0	14.0	15.0	15.0	5000	10.0
	max.	< 10.0	10.0	44.0	39.0	29.0	23.0	58.0	58.0		
	avg.	< 10.0	< 10.0	35.5	29.5	21.0	18.5	36.5	36.5		

Notes:

See Figure 5-2 for the locations of recharge basins/outfalls.

AGS = Alternating Gradient Synchrotron

AWQS = Ambient Water Quality Standards

Linac = Linear Accelerator

MDL = minimum detection limit

samples, as flow allowed.

The radiological data from Peconic River surface water samples collected during 2014 are summarized in Table 5-5. Radiological analysis of water samples collected both upstream and downstream of the STP discharge and from background locations had very low concentrations of gross alpha and gross beta activity. The maximum concentrations of gross alpha activity were found at stations HV and HY, both located upstream of the STP and the

maximum beta activities were found at stations HA, located off site and HH, the control location. The average concentrations from off-site and control locations were slightly higher than BNL on-site levels. The beta activity for all locations is therefore attributed to natural sources. All detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the STP, and tritium was not detected above method

Figure 5-4. Sampling Stations for Surface Water, Fish, and Shellfish.

detection limits in any of the surface water samples.

Monitoring for Sr-90 was performed at all but one Peconic River station and the Carmans River control location in 2014. A sample from Station HV was not collected due to no water flow conditions. Low-level detections were found at six of the ten sampling stations, including the control location HH (Carmans River) at very consistent levels. All concentrations were much less than the NYS DWS of 8 pCi/L, are consistent with historical levels, and can be attributed to worldwide fallout.

5.5.2 Peconic River – Nonradiological Analyses

River water samples collected in 2014 were analyzed for water quality parameters (pH, temperature, conductivity, and dissolved oxygen), anions (chlorides, sulfates, and nitrates), metals, and VOCs. The analytical data for the Peconic River and Carmans River samples are summarized in Table 5-6 (water quality) and Table 5-7 (metals). There were no VOCs detected above the method detection limits from any of the Peconic River or Carmans River sampling stations in 2014.

With the exception of Station HM-N, Peconic River water quality data collected upstream and downstream showed that water quality was consistent throughout the river system. The data were also consistent with water samples collected from the Carmans River control location (HH). Sulfates and nitrates tend to be slightly higher in samples collected immediately downstream of the STP discharge (Station HM-N) and were consistent with the concentrations in the STP discharge. Chlorides were also highest at Station HM-N, which is immediately downstream of the STP outfall, and were likely a result of road salting operations at the Laboratory. There are no NYS AWQS imposed for

Table 5-5. Radiological Results for Surface Water Samples from the Peconic and Carmans Rivers.

Sampling Station		Gross Alpha	Gross Beta	Tritium	Sr-90
		(pCi/L)			
Peconic River					
HY (headwaters) on site, west of the RHIC ring	N	2	2	2	2
	max	2.35 ± 1.12	2 ± 0.7	< 351	< 0.38
	avg	2.28 ± 0.13	1.6 ± 0.79	< MDL	-0.02 ± 0.29
HV (headwaters) on site, inside the RHIC ring	N	2	2	2	NS
	max	2.51 ± 1.11	1.11 ± 0.62	< 341	
	avg	1.53 ± 1.92	0.81 ± 0.58	< MDL	
HE upstream of STP outfall	N	2	2	2	2
	max	< 1.75	1.45 ± 0.69	< 477	0.32 ± 0.12
	avg	0.62 ± 0.66	0.9 ± 1.07	< MDL	0.19 ± 0.26
HM-N downstream of STP, on site	N	4	4	4	4
	max	< 1.67	5.04 ± 0.86	< 304	0.61 ± 0.16
	avg	0.25 ± 0.43	2.71 ± 1.93	< MDL	0.19 ± 0.28
HM-S tributary, on site	N	2	2	2	2
	max	1.38 ± 0.92	< 0.88	< 320	0.4 ± 0.23
	avg	0.82 ± 1.09	0.65 ± 0.31	< MDL	0.18 ± 0.43
HQ downstream of STP, at BNL site boundary	N	1	1	1	1
	max	< 1.2	< 0.85	< 316	< 0.61
	avg	NA	NA	NA	NA
HA off site	N	2	2	2	2
	max	< 1.77	65.9 ± 7.13	< 302	< 0.27
	avg	0.74 ± 0.67	33.41 ± 63.68	< MDL	0.18 ± 0.05
Donahue's Pond off site	N	2	2	2	2
	max	< 1.39	7.82 ± 1.36	< 302	0.32 ± 0.13
	avg	0.63 ± 0.29	4.38 ± 6.75	< MDL	0.25 ± 0.14
Forge Pond off site	N	2	2	2	2
	max	< 1.38	6.65 ± 1.21	< 373	0.19 ± 0.12
	avg	-0.01 ± 0.35	3.89 ± 5.41	< MDL	0.17 ± 0.03
Carmans River HH control location, off site	N	2	2	2	2
	max	< 1.62	44.2 ± 4.95	< 375	0.28 ± 0.13
	avg	0.94 ± 0.02	22.6 ± 42.33	< MDL	0.18 ± 0.19
Swan Pond control location, off site	N	2	2	2	2
	max	1.21 ± 0.77	6.57 ± 1.19	< 302	< 0.22
	avg	0.66 ± 1.07	3.6 ± 5.82	< MDL	-0.02 ± 0.07
SDWA Limit (pCi/L)		15	(a)	20,000	8

Notes:

See Figure 5-4 for the locations of sampling stations.

All values reported with a 95% confidence interval.

Negative numbers occur when the measured values are lower than background (see Appendix B).

To convert values from pCi to Bq, divide by 27.03.

(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

MDL = Method Detection Limit

N = Number of samples analyzed

NA = Not Applicable

NS = Not Sampled for this analyte

RHIC = Relativistic Heavy Ion Collider

SDWA = Safe Drinking Water Act

STP = Sewage Treatment Plant

Table 5-6. Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers.

Analyte		Peconic River Station Locations										NYSDEC Effluent Standard	Typical MDL
		HY	HE	HM-N	HM-S	HQ	HA	Donahue's Pond	Forge Pond	Swan Pond	(Control) HH		
No. of samples		2	2	4	2	1	2	2	2	2	2	6.5-8.5	NA
pH (SU)	min.	5.7	6.2	6.9	4.0	NA	6.0	5.5	6.2	5.6	6.3		
	max.	7.6	6.4	9.0	4.2	6.6	6.6	6.7	7.6	6.9	6.4		
Conductivity (µS/cm)	min.	84	57	67	41	NA	56	69	40	16	135	SNS	NA
	max.	95	145	536	90	86	123	91	141	118	159		
	avg.	90	101	349	66	NA	90	80	91	67	147		
Temperature (°C)	min.	9.9	8.2	2.7	7.7	NA	9.7	5.5	2.2	7.4	12.9	SNS	NA
	max.	18.1	8.2	22.2	8.4	9.7	20.6	24.3	23.5	23.4	20.6		
	avg.	14.0	8.2	10.5	8.1	NA	15.2	14.9	12.8	15.4	16.7		
Dissolved oxygen (mg/L)	min.	7.0	9.8	11.5	7.3	NA	3.7	6.3	8.2	3.8	8.4	>4.0	NA
	max.	8.5	9.8	13.3	10.1	10.7	8.4	9.6	11.4	10.1	9.2		
	avg.	7.8	9.8	12.3	8.7	NA	6.1	8.0	9.8	7.0	8.8		
Chlorides (mg/L)	min.	8.8	17.0	21.0	4.0	NA	6.5	11.0	13.0	3.5	35.0	250(a)	4.0
	max.	24.0	20.0	82.0	7.5	16.0	12.0	13.0	25.0	13.0	38.0		
	avg.	16.4	18.5	60.5	5.8	NA	9.3	12.0	19.0	8.3	36.5		
Sulfates (mg/L)	min.	2.5	9.7	7.3	2.7	NA	1.5	2.3	6.1	0.3	12.0	250(a)	0.5
	max.	2.7	10.0	19.0	4.0	4.3	7.9	7.3	13.0	5.7	12.0		
	avg.	2.6	9.9	14.6	3.4	NA	4.7	4.8	9.6	3.0	12.0		
Nitrate as nitrogen (mg/L)	min.	0.05	0.03	0.11	0.01	NA	< 0.05	0.04	0.03	0.01	1.50	10(a)	0.05
	max.	0.40	0.04	9.00	0.14	0.55	< 0.05	< 0.05	0.11	< 0.05	1.80		
	avg.	0.22	0.03	3.33	0.08	NA	< 0.05	< 0.05	0.07	< 0.05	1.65		

Notes:

See Figure 5-2 for the locations of recharge basins/outfalls.

(a) Since there are no NYSDEC Class C surface Ambient Water Quality Standards (AWQS) for these compounds, the AWQS for groundwater is provided, if specified.

Donahue's Pond = Peconic River, off site

Forge Pond = Peconic River, off site

HA = Peconic River, off site

HE = Peconic River, upstream of STP Outfall

HH = Carmans River control location, off site

HM-N = Peconic River on site, downstream of STP

HM-S = Peconic River tributary, on site

HQ = Peconic River, downstream of STP at BNL site boundary

HY = Peconic River headwaters, on site, east of Wm Floyd Pkwy.

MDL = Minimum Detection Limit

NA = Not Applicable

NYSDEC = New York State Department of Environmental Conservation

SNS = Effluent Standard Not Specified

chloride or sulfates in discharges to surface water; however, since the Peconic River recharges to groundwater, the AWQS for groundwater (250 mg/L) for these substances is used for comparison purposes.

Ambient water quality standards for metallic elements are based on their solubility state. Certain metals are only biologically available to aquatic organisms if they are in a dissolved or ionic state, whereas other metals are toxic in any form (i.e., dissolved and particulate combined). In 2014, the BNL monitoring program continued to assess water samples for both

the dissolved and particulate form. Dissolved concentrations were determined by filtering the samples prior to acid preservation and analysis. Examination of the total (i.e., particulate form) metals data showed that silver, aluminum, copper, iron, lead, and zinc were present in concentrations at some locations that exceeded NYS AWQS. Aluminum and iron are detected throughout the Peconic and Carmans Rivers at concentrations that exceed the NYS AWQS in both the filtered and unfiltered fractions. Iron and aluminum are found in high concentrations in native Long Island soil and, for iron, at high

Table 5-7. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers.

METAL	Peconic River Locations																		Forge Pond	Control HH		NYSDEC AWQS	Typical MDL
	HY		HE		HM-N		HM-S		HQ		HA		DP		Swan Pond		Forge Pond			Control HH			
Total or Dissolved	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	
No. of samples	2	2	1	1	5	3	1	1	4	2	2	2	2	2	2	2	2	2	2	2	2	2	
Ag (I) Silver (µg/L)	min.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	2.2	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
Al (I) Aluminum (µg/L)	min.	510.0	66.0	210.0	82.0	58.0	< 50.0	700.0	660.0	NA	NA	< 50	< 50.0	50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	
	max.	650.0	650.0	370.0	340.0	380.0	310.0	720.0	780.0	420.0	300.0	85.0	62.0	92.0	78.0	< 50.0	< 50.0	67.0	< 50.0	58.0	< 50.0	< 50.0	
	avg.	580.0	358.0	290.0	211.0	173.5	114.5	710.0	720.0	NA	NA	60.5	< 50.0	71.0	61.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	< 50.0	
As (D) Arsenic (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	
Ba Barium (µg/L)	min.	< 20.0	< 20.0	20.0	< 20.0	< 20.0	< 20.0	< 20.0	NA	NA	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	36.0	< 20.0	< 20.0	
	max.	29.0	< 20.0	24.0	23.0	23.0	22.0	< 20.0	< 20.0	< 20.0	< 20.0	45.0	29.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	38.0	< 20.0	< 20.0	
	avg.	21.0	< 20.0	22.0	21.0	< 20.0	< 20.0	< 20.0	< 20.0	NA	NA	27.5	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	37.0	< 20.0	< 20.0	
Be (AS) Beryllium (µg/L)	min.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
Cd (D) Cadmium (µg/L)	min.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 4.0	< 4.0	< 2.0	< 2.0	NA	NA	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	
Co (AS) Cobalt (µg/L)	min.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	
Cr (I) Chromium (µg/L)	min.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	NA	NA	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	
	max.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 20.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 20.0	< 10.0	< 10.0	NA	NA	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	
Cu (D) Copper (µg/L)	min.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	
	max.	16.0	< 10.0	< 10.0	< 10.0	< 10.0	25.0	24.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	14.7	12.3	< 10.0	< 10.0	NA	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	

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Table 5-7. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers.

METAL	Peconic River Locations																				Forge Pond		Swan Pond		Control HH		NYSDEC AWQS	Typical MDL		
Total or Dissolved No. of samples	HY		HE		HM-N		HM-S		HQ		HA		DP		T		D		T		D		T	D	T	D	T	D		
Fe (AS) Iron (mg/L)	2	2	1	1	3	5	2	0.1	0.2	0.2	NA	NA	NA	0.4	0.3	0.4	0.2	0.1	0.1	0.3	0.2	0.4	0.2	2	2	2	2	2	0.075	
	min.	0.3	0.2	0.5	0.3	0.2	0.2	0.2	0.2	0.2	NA	NA	NA	0.4	0.3	0.4	0.2	0.1	0.1	0.3	0.2	0.4	0.2	2	2	2	2	2	0.075	
	max.	0.8	0.3	1.2	0.4	0.5	0.4	0.2	0.2	0.2	0.2	0.1	0.4	0.4	3.4	2.7	2.2	0.2	0.1	0.4	0.3	15.0	0.3	2	2	2	2	2	0.075	
	avg.	0.6	0.2	0.8	0.3	0.3	0.2	0.2	0.2	0.2	0.2	NA	NA	NA	0.4	1.9	1.5	1.2	0.2	0.1	0.4	0.2	7.7	0.3	2	2	2	2	0.075	
Hg (D) Mercury (µg/L)	min.	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	
	max.	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	
	avg.	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	
	min.	29.0	17.0	70.0	49.0	5.4	3.4	34.0	34.0	NA	NA	59.0	60.0	42.0	46.0	99.0	87.0	27.0	110.0	83.0	2	2	2	2	2	2	2	2	2	2
Mn Manganese (µg/L)	max.	42.0	45.0	110.0	110.0	67.0	63.0	47.0	53.0	26.0	23.0	64.0	1300.0	220.0	210.0	280.0	170.0	69.0	61.0	1600.0	110.0	SNS	SNS	SNS	SNS	SNS	SNS	SNS	2	2
	avg.	35.5	31.0	90.0	79.5	25.6	21.4	40.5	43.5	NA	NA	61.5	680.0	131.0	128.0	189.5	128.5	58.0	44.0	855.0	96.5	2	2	2	2	2	2	2	2	2
	min.	9.7	8.7	10.0	11.0	15.0	15.0	3.2	3.1	NA	NA	4.3	4.5	7.1	7.4	2.4	2.4	7.0	6.7	12.0	23.0	1	1	1	1	1	1	1	1	1
	max.	15.0	16.0	12.0	11.0	87.0	79.0	3.5	3.9	12.0	12.0	25.0	12.0	13.0	12.0	11.0	11.0	23.0	21.0	32.0	32.0	SNS	SNS	SNS	SNS	SNS	SNS	SNS	1	1
Na Sodium (mg/L)	avg.	12.4	12.4	11.0	11.0	55.5	51.5	3.4	3.5	NA	NA	14.7	8.3	10.1	9.7	6.7	6.7	15.0	13.9	17.0	27.5	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	min.	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	NA	NA	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	1.1
	max.	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	1.1
	avg.	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	NA	NA	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	1.1
Pb (D) Lead (µg/L)	min.	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	NA	NA	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3	
	max.	3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3
	avg.	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	NA	NA	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3
	min.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	NA	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
Sb Antimony (µg/L)	max.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	avg.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	min.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	NA	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	max.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
Se (D) Selenium (µg/L)	avg.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	min.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	NA	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	max.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	avg.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
Tl (AS) Thallium (µg/L)	min.	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	NA	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	max.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
	avg.	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5

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Table 5-7. Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers (concluded).

METAL	Peconic River Locations																Control HH	NYSDEC AWQS	Typical MDL	
	HY		HE		HM-N		HM-S		HQ		HA		DP		Swan Pond					Forge Pond
Total or Dissolved	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
No. of samples	2	2	1	1	5	3	1	1	4	2	2	2	2	2	2	2	2	2	2	2
V (AS) Vanadium (µg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
	9.3	6.6	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
	6.3	< 5.0	< 5.0	< 5.0	< 10.0	< 10.0	< 5.0	< 5.0	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Zn (D) Zinc (µg/L)	21.0	23.0	20.0	18.0	23.0	24.0	15.0	18.0	NA	NA	12.0	15.0	20.0	21.0	11.0	13.0	< 10.0	14.0	14.0	14.0
	42.0	24.0	31.0	41.0	39.0	39.0	30.0	31.0	20.0	21.0	78.0	92.0	81.0	63.0	96.0	63.0	< 50.0	62.0	68.0	68.0
	31.5	23.5	25.5	29.5	29.3	28.5	22.5	24.5	NA	NA	45.0	53.5	50.5	42.0	52.6	38.0	< 50.0	25.3	38.0	41.0

Notes:

See Figure 5-4 for the locations of sampling stations.

AWQS = Ambient Water Quality Standards

AS = Acid Soluble

D = Dissolved
DP = Donahue's Pond
NA = Not ApplicableSNS = Effluent Standard Not Specified for these elements
in Class C Surface Waters
T = Total

levels in groundwater. Levels of silver, copper, lead, and zinc at concentrations greater than the NYS AWQS were found in samples collected throughout the Peconic River system and the Carmans River control location (HH). The concentrations detected were consistent with those found in the STP discharge and, in all instances, were below the BNL SPDES permit limits. The NYS AWQS limits for copper, lead, and zinc are very restrictive; consequently, BNL's SPDES permit allows higher limits, provided toxicity testing shows no impact to aquatic organisms. Filtration of the samples reduced concentrations of most metals to below the NYS AWQS, indicating that most detections were due to sediment carryover.

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Natural and Cultural Resources

The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on understanding the site's resources and on maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with on-site personnel and the public on ecological issues. BNL focuses on protecting both Federal and New York State threatened and endangered species on site, as well as continuing the Laboratory's leadership role within the greater Long Island Central Pine Barrens ecosystem. Monitoring to determine whether current or historical activities are affecting natural resources is also part of the program. In 2014, deer, fish, and vegetation sampling results were consistent with previous years.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL historic resources is established and maintained. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of identified resources to on-site personnel and the public for research and interpretation.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The Natural Resource Management Program at BNL promotes stewardship of the natural resources found at the Laboratory, and integrates natural resource management and protection with the Laboratory's scientific mission. BNL's Natural Resource Management Plan (NRMP) describes the program strategy, elements, and planned activities for managing the various natural resources found on site. The NRMP is updated every five years (BNL 2011).

6.1.1 Identification and Mapping

An understanding of an environmental baseline is the foundation of natural resource management planning. BNL uses digital global positioning systems (GPS) and geographic information systems (GIS) to clearly relate various "layers" of geographic information (e.g., vegetation types, soil condition, habitat, forest health, etc.). This is done to gain insight into

interrelationships between the biotic systems and physical conditions at the Laboratory.

In 2012, a forest fire was started on the northern part of the BNL site, burning approximately 300 acres and an additional 700 acres off site. Within two days of the fire, BNL natural resource personnel began recording the extent of the fire using GPS, established photo points, and began tracking both fire damage and post-fire recovery. Maps of the fire and photo locations were entered into the GIS for future reference and the burned areas are revisited periodically to track recovery. A deer exclosure area was established to track impacts of BNL's high deer population on the burn area as it continues to recover.

Work associated with tracking impacts from the construction of the Long Island Solar Farm (LISF) at BNL continue to be entered into the GIS as a tool to assist analysis of changes to wildlife populations and vegetation. In 2014, natural resource personnel and interns

continued to look at use of the LISF site by wildlife; use of fence openings by wildlife; changes in bird use; and changes in vegetation.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years or are expected to be present on site (see Table 6-1). The only New York State endangered species confirmed as currently inhabiting Laboratory property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Six other New York State endangered species have been identified at BNL in the past or are possibly present including: the Persius duskywing butterfly (*Erynnis p. persius*), the crested fringed orchid (*Plantathera cristata*), Engelman spikerush (*Eleocharis engelmannii*), fireweed (*Erectites heiracifolia* var. *megalocarpa*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifoli*).

Seven New York State threatened species have been positively identified on site and three other species are considered likely to be present. Threatened species include two fish, the banded sunfish (*Enneacanthus obesus*) and swamp darter (*Etheostoma fusiforme*); and plants, including the stiff-leaved goldenrod (*Oligoneuron rigida*), stargrass (*Aletris farinose*), and eastern showy aster (*Eurybia spectabilis*). The northern harrier (*Circus cyaneus*) is periodically seen in the fall. Insects listed as threatened include the Pine Barrens bluet (*Enallagma recurvatum*), a damselfly, which was confirmed at one of the many coastal plain ponds located on site. Two other damselflies, the little bluet (*Enallagma minisculum*) and the scarlet bluet (*Enallagma pictum*), are likely to be present at one or more of the ponds on site. The frosted elfin (*Callophrys irus*), a butterfly, has been historically present on site due to its preferred habitat and host plant, wild lupine (*Lupinus perennis*).

A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been

identified historically are listed in Table 6-1.

BNL historically has had no federally threatened or endangered species present on site. On October 2, 2013, the U.S. Fish & Wildlife Service (FWS) published a notice in the Federal Register that the northern long-eared bat (*Myotis septentrionalis*) be recommended for listing as an Endangered Species under the Federal Endangered Species Act. The comment period was extended two times with a final determination to be completed late in 2014 and listing to occur in early 2015. The northern long-eared bat is known to be present at BNL, having been identified as the first case of white-nosed syndrome found on Long Island in 2011. Work on identifying bats continued in 2014 and is discussed in Section 6.5.

6.1.2 Habitat Protection and Enhancement

BNL has administrative processes in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on endangered, threatened, or sensitive species are either incorporated into Laboratory procedures or into specific program or project plans. Human access to critical habitats, when necessary, is limited, and habitats are enhanced to improve survival or increase populations. Routine activities, such as road maintenance, are not performed until the planned activities have been evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

Many safeguards are in place to protect eastern tiger salamander breeding areas. BNL staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts. A map of the breeding areas is reviewed when new projects are proposed. The map is updated as new information concerning the salamanders is generated through research and monitoring. The current map incorporates buffer areas around tiger salamander habitats of 1,000 feet based on guidance from the New York State Department of Environmental Conservation (NYSDEC). Other efforts to protect this state-endangered species include determining when

adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed or closely monitored.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with NYSDEC, habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed 26 on-site ponds that are used by eastern tiger salamanders. In 2014, egg mass surveys confirmed the presence of salamanders in 5 of the 26 ponds. Whenever possible, ponds with documented egg masses from the spring surveys are revisited in June and July to check for the presence of larval salamanders.

Protection of the eastern tiger salamander was a key component of the Environmental Assessment (EA) conducted for the LISF project. The unique shape of the LISF facility is, in part, the result of a need to provide sufficient, viable habitat for the tiger salamander. In 2010, the LISF project completed habitat enhancements to improve one pond in the area, with the enhancements intended to allow the pond to retain water for longer periods of time to support larval development. The enhanced pond is currently being managed to remove invasive plants that moved into the pond from surrounding areas. Several areas of the LISF have maintained standing water since construction, and these areas have been monitored for use by amphibians but have not been identified as supporting tiger salamanders.

6.1.2.2 Banded Sunfish

Banded sunfish protection efforts include observing whether adequate water is present within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place in ponds and the Peconic River on site for potential impacts on these habitats. Population estimates are periodically conducted within these waters to determine their current health. During the last population

Table 6-1. New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL.

Common Name	Scientific Name	State Status	BNL Status
Insects			
Black-bordered lemon moth	<i>Marimatha nigrofimbria</i>	SGCN	Confirmed
Comet darter	<i>Anax longipes</i>	SGCN	Confirmed
Frosted elfin	<i>Callophrys iris</i>	T	Likely
Little bluet	<i>Enallagma minusculum</i>	T	Likely
Mottled duskywing	<i>Erynnis martialis</i>	SC	Likely
New England bluet	<i>Enallagma laterale</i>	SGCN	Likely
Persius duskywing	<i>Erynnis persius persius</i>	E	Likely
Pine Barrens bluet	<i>Enallagma recurvatum</i>	T	Confirmed
Pine barrens zanclognatha	<i>Zanclognatha martha</i>	SGCN	Confirmed
Scarlet bluet	<i>Enallagma pictum</i>	T	Likely
Fish			
Banded sunfish	<i>Enniacanthus obesus</i>	T	Confirmed
Swamp darter	<i>Etheostoma fusiforme</i>	T	Confirmed
Amphibians			
Eastern spadefoot toad	<i>Scaphiopus holbrookii</i>	SC	Confirmed
Eastern tiger salamander	<i>Ambystoma tigrinum tigrinum</i>	E	Confirmed
Four-toed salamander	<i>Hemidactylium scutatum</i>	SGCN	Confirmed
Fowler's toad	<i>Bufo fowleri</i>	SGCN	Confirmed
Marbled salamander	<i>Ambystoma opacum</i>	SC	Confirmed
Reptiles			
Eastern box turtle	<i>Terrapene carolina</i>	SC	Confirmed
Eastern hognose snake	<i>Heterodon platyrhinos</i>	SC	Confirmed
Eastern ribbon snake	<i>Thamnophis sauritus</i>	SGCN	Confirmed
Northern black racer	<i>Coluber constrictor</i>	SGCN	Confirmed
Snapping turtle	<i>Chelydra serpentina</i>	SGCN	Confirmed
Spotted turtle	<i>Clemmys guttata</i>	SC	Confirmed
Stinkpot turtle	<i>Sternotherus odoratus</i>	SGCN	Confirmed
Worm snake	<i>Carphophis amoenus</i>	SC	Confirmed
Birds (nesting, transient, or potentially present)			
Black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>	SGCN	Confirmed
Blue-winged warbler	<i>Vermivora pinus</i>	SGCN	Confirmed
Brown thrasher	<i>Toxostoma rufum</i>	SGCN	Confirmed
Cooper's hawk	<i>Accipiter cooperii</i>	SC	Confirmed
Glossy ibis	<i>Plegadis falcinellus</i>	SGCN	Confirmed
Grasshopper sparrow	<i>Ammodramus savannarum</i>	SC	Confirmed
Great egret	<i>Ardea alba</i>	SGCN	Confirmed
Horned lark	<i>Eremophila alpestris</i>	SC	Confirmed
Northern bobwhite	<i>Colinus virginianus</i>	SGCN	Confirmed
Northern harrier	<i>Circus cyaneus</i>	T	Confirmed
Osprey	<i>Pandion haliaetus</i>	SC	Confirmed
Prairie warbler	<i>Dendroica discolor</i>	SGCN	Confirmed
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	SC	Confirmed
Scarlet tanager	<i>Piranga olivacea</i>	SGCN	Confirmed
Sharp-shinned hawk	<i>Accipiter striatus</i>	SC	Confirmed
Whip-poor-will	<i>Caprimulgus vociferus</i>	SC	Confirmed
Wood thrush	<i>Hylocichla mustelina</i>	SGCN	Confirmed
Plants			
Bayberry	<i>Myrica pensylvanica</i>	V	Confirmed
Bracken fern**	<i>Pteridium alquilinum</i> var. <i>pseudocaudatum</i>	E	Possible
Butterfly weed	<i>Asclepias tuberosa</i> ssp. <i>interior</i>	V	Confirmed
Cinnamon fern	<i>Osmunda cinnamomea</i>	V	Confirmed

(continued on next page)

Table 6-1. New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL (concluded).

Common Name	Scientific Name	State Status	BNL Status
Clayton's fern	<i>Osmunda claytoniana</i>	V	Confirmed
Crested fringed orchid	<i>Plantanthera cristata</i>	E	Likely
Dwarf huckleberry	<i>Gaylussacia bigeloviana</i>	E	Confirmed
Eastern showy aster**	<i>Eurybia spectabilis</i>	T	Confirmed
Engelman spikerush	<i>Eleocharis engelmannii</i>	E	Confirmed
Fireweed**	<i>Erectites heiracifolia</i> var. <i>megallocarpa</i>	E	Possible
Flowering dogwood	<i>Cornus florida</i>	V	Confirmed
Green fringed orchid	<i>Platanthera lacera</i>	V	Confirmed
Ground pine	<i>Dendrolycopodium obscurum</i>	V	Confirmed
Long-beaked bald-rush	<i>Rhynchospora scirpoides</i>	R	Confirmed
Marginal wood fern	<i>Dryopteris marginalis</i>	V	Confirmed
Marsh fern	<i>Thelypteris palustris</i> var. <i>pubescens</i>	V	Confirmed
Narrow-leaved bush clover	<i>Lespedeza augustifolia</i>	R	Confirmed
New York fern	<i>Thelypteris novaboracensis</i>	V	Confirmed
Pink lady's slipper	<i>Cypripedium acaule</i>	V	Confirmed
Possum hawk**	<i>Viburnum nudum</i> var. <i>nudum</i>	E	Possible
Prostate knotweed**	<i>Polygonum aviculare</i> ssp. <i>buxiforme</i>	E	Possible
Round-leaved sundew	<i>Drosera rotundifolia</i> var. <i>rotundifolia</i>	V	Confirmed
Royal fern	<i>Osmunda regalis</i>	V	Confirmed
Sheep laurel	<i>Kalmia angustifolia</i>	V	Confirmed
Small-flowered false foxglove	<i>Agalinis paupercula</i>	R	Confirmed
Spotted wintergreen	<i>Chimaphila maculata</i>	V	Confirmed
Stargrass	<i>Aletris farinosa</i>	T	Confirmed
Stiff-leaved goldenrod	<i>Oligoneuron rigida</i>	T	Confirmed
Swamp azalea	<i>Rhododendron viscosum</i>	V	Confirmed
Virginia chain-fern	<i>Woodwardia virginica</i>	V	Confirmed
Whorled loosestrife	<i>Lysimachia quadrifolia</i>	E	Confirmed
Wild lupine	<i>Lupinus perennis</i>	R	Confirmed
Winterberry	<i>Ilex verticillata</i>	V	Confirmed

Notes:

* Table information based on 6 NYCRR Part 182, NYCRR Part 193, and BNL survey data.

** Species added in 2014

No federally listed threatened or endangered species are known to occur at BNL.

E = endangered

R = rare

T = threatened

SC = species of special concern

SGCN = species of greatest conservation need

V = exploitably vulnerable

6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along seven permanent bird survey routes in various habitats on site. A new route was established in 2010 in the vicinity of the LISF.

In 2014, monthly surveys were conducted starting at the end of April and extending through the end of August. Two routes associated with the LISF were monitored twice monthly from the end of April through mid-September. These surveys identified 70 songbird species, compared to the 74 species identified in 2013 and 69 species in 2012. A total of 132 bird species have been identified in surveys in the past 14 years; 59 of these species were present in each of the past 15 years. Variations in the number and species identified during each survey may reflect the time of observation, variations in weather patterns between years, and possible changes in the environment. The three most diverse transects pass near on-site wetlands near the LISF and the Peconic River. The four transects passing through the various forest types on site (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study.

In 2013, BNL worked with a statistician to analyze 13 years of collected data. This effort found that 20 percent of the bird species accounted for 80 percent of the number of birds detected on bird surveys. This is known as the Pareto Principle, or the 80-20 rule: approximately 80 percent of the effects come from 20 percent of the causes (Rispoli, et al. 2014). Statistical analysis of the bird survey data continued in 2014.

No known data on the effects of a large, utility-scale solar array such as the LISF are known within scientific literature. To assess the effects of the solar farm on local bird populations, the collection of migratory bird data in both the Biology Field transect and the LISF transect

survey in 2011, approximately 6,400 banded sunfish were counted. In 2014, in conjunction with NYSDEC, tissue samples from banded sunfish were obtained from several ponds within the Peconic River drainage to further investigate the genetic relationships of the various isolated populations of this fish. Work was conducted by student researchers under the direction of a research teacher in Sayville, New York.

is important. It is currently predicted that the LISF will improve habitat for some migratory birds over time, as understory vegetation grows below the arrays and deer are kept out of the area. One species, the indigo bunting (*Passerina cyanea*), was absent along the Biology Field transect in 2011, but was heard along the solar farm transect in 2012, returned to the Biology Field transect in 2013, and was present on both transects in 2014. This temporary absence is thought to be due to disturbance from construction activities while building the LISF.

The eastern bluebird (*Sialia sialis*) has been identified as a declining species of migratory birds in North America. This is due to loss of habitat and nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). BNL's NRMP includes habitat enhancement for the eastern bluebird. Since 2000, the Laboratory has installed more than 56 nest boxes around open grassland areas on site to enhance their population. Although many of these boxes were removed from service in 2010 in preparation for the construction of the LISF, the LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty new boxes were installed around the northern most portions of the solar farm in 2012.

Migratory birds occasionally cause safety and health concerns, particularly Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas on site. Over the past several years, the resident Canada goose population at BNL began increasing, with the potential to reach large enough numbers that could result in health and safety issues. In 2007, under a permit from FWS, the Laboratory began managing the resident goose population by limiting the number of eggs that could hatch. In 2014, 25 nests were treated and approximately 24 goslings were produced. By the end of 2014, the goose population was estimated at just over 100 birds.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, the

Laboratory also monitors and manages other populations, including species of interest, to ensure that they are sustained and to control invasive species.

6.1.3.1 Wild Turkey

The forested areas of BNL provide good nesting and foraging habitat for wild turkey (*Meleagris gallapavo*). In 2014, the on-site population was approximately 300 birds. In 2009, the wild turkey population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting. Each year, NYSDEC manages a five-day hunting period for several areas across Long Island, which typically results in over 100 birds taken.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site, and hunting is currently not permitted at the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. Normally, a population density of 10 to 30 deer per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the Laboratory property under optimal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting routine population surveys of the white-tailed deer since 2000. The fall 2014 survey estimated the population at approximately 830 animals.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries to both humans and animals), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (collision damage to autos and browsing damage to ornamental plantings). Deer related collisions on site are less common than in the past, presumably due to improved vehicular speed controls and employee training.

High deer populations are a regional problem,

and the Laboratory is just one area on Long Island with such an issue. In 2012, several governmental entities on eastern Long Island began working to manage deer populations and the USDA-Wildlife Services, in cooperation with NYSDEC and the Suffolk County Farm Bureau, planned a limited culling operation. Culling was to start in several of Long Island's east end towns in late 2013, but was delayed to early 2014 due to public concerns about the program. The program eventually resulted in 192 deer taken in just one east end town.

In 2008, BNL began developing a deer management plan which included an option to reduce the population through culling. The planning effort included engagement of Laboratory employees and guests in discussions concerning the need and methods for deer management. In 2012, an EA under the National Environmental Policy Act (NEPA) was completed and sent to NY State for comment. The Final EA was completed in the spring of 2013. Additionally, under BNL's permit for deployment of the 4-Poster tick management system issued by NYSDEC, the Laboratory is required to implement a deer management program. Planning for implementing the deer cull continued through 2014 with a contract to reduce the deer population by 300 animals being in place at year's end.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL ensures that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory uses NEPA reviews when identifying potential environmental impacts associated with site activities, especially projects that may result in physical alterations to the landscape and structures. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York. No Environmental Assessments were conducted in 2014.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

The Upton Ecological and Research Reserve (Upton Reserve) consists of 530 acres located on the eastern boundary of the BNL site. The reserve has been designated as an area for the protection of sensitive habitats and a place where researchers can study local ecosystems. The Upton Reserve is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994–1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

The Upton Reserve is managed by BNL and the Foundation for Ecological Research in the Northeast (FERN). Funding is coordinated for research projects that occur within the reserve and the larger pine barrens area of Long Island. Research supported by FERN in 2014 includes: formal results of the work on leopard frogs was published in which a new species, *Rana (Lithobates) kauffeldi*, was described from locations on Staten Island (Feinberg, et. al 2014). Other research supported by FERN included continued investigation into bat populations on Long Island that were impacted by white-nosed syndrome and the funding of a leopard frog identification guide to help differentiate the newly discovered species of leopard frog in the northeast. Information on these projects and others is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on site. In addition to surveillance monitoring, routine CERCLA-required monitoring results associated with post-cleanup monitoring of the Peconic River is also conducted. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces of Cs-137 can be found in deer and in other animals and plants on site. At the cellular level, Cs-137 takes the place

of potassium (K), an essential nutrient. Most radionuclide tables in this chapter also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found in flora and fauna. Studies indicate that Cs-137 out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allow for a comparison with Cs-137 levels and is used, in part, to determine the accuracy of analytical results. The results of the annual sampling conducted under the flora and fauna monitoring program follow.

6.3.1 Deer Sampling

White-tailed deer in New York State are typically large, with males weighing, on average, approximately 150 pounds; females typically weigh approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The meat available for consumption from local deer ranges from 20 to 40 pounds per animal. This fact has implications for calculating the potential radiation dose to consumers of deer meat containing Cs-137, because smaller deer do not provide sufficient amounts of meat (flesh) to support the necessary calculations. Samples of meat and liver are taken from each deer, when possible, and are analyzed for Cs-137. Data are reported on a wet-weight basis, as that is the form most likely used for consumption.

Since 1996, BNL has routinely collected deer samples from on- and off-site areas. While most off-site samples are the result of car/deer accidents near the Laboratory, in most years, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than 1 mile from BNL are used. Based on more than a decade of sampling, deer taken from more than 1 mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source. In 2014, five deer were obtained on site, five from off-site locations within 1 mile of the Laboratory, and six from areas greater than 1 mile from the BNL boundary. The results of deer sampling are shown in Table 6-2.

6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), most likely because they graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing/grazing animals or is consumed directly while the animal is grazing.

Removal of contaminated soil areas on site has occurred under the Laboratory's cleanup program, with all major areas of contaminated soil being remediated by September 2005. The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the number of deer obtained from 2005 to 2014 was significantly lower. In 1998, a statistical analysis suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. The number obtained each year has not met this preferred level because sample availability depends on accidents between vehicles and deer and people reporting dead deer. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2010. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. This distribution is most likely due to the fact that people on their way to work see and report dead deer. Vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active and traffic to and from the front gate is greatest.

In 2014, Cs-137 concentrations in deer meat samples were obtained from five deer on site with a range of values from 0.02 pCi/g, wet weight, to 1.46 pCi/g, wet weight, and an arithmetic average of 0.60 pCi/g, wet weight, as shown in Table 6-2. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than

Figure 6-1. Deer Sample Locations, 2009—2014.

wet weight values. The highest on-site sample in 2014 (1.46pCi/g, wet weight) was about 2 times higher than the highest on-site sample reported in 2013 (0.85 pCi/g, wet weight) and 8 times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight).

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within 1 mile of BNL (five samples) and samples taken farther away (six samples), as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from non-detect to 1.93 pCi/g, wet weight, with an arithmetic average of 0.56 pCi/g, wet weight. Because deer on site may routinely travel up to 1 mile off site, the arithmetic average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2014, this was 0.58 pCi/g, wet weight. Deer samples from greater than 1 mile from BNL ranged from 0.10 pCi/g, wet weight, to 0.35 pCi/g, wet weight, with the arithmetic average being 0.32 pCi/g, wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2014 from four different location groupings; 2013 was the first year in which the average Cs-137 content from deer taken within 1 mile of the Laboratory was lower than the on-site average, and this result was repeated again in 2014. While no definitive explanation can be given to the difference from past results, it could simply be an artifact of low sample numbers and randomness in sample acquisition. Although not shown on the figure, 88 percent of all meat samples taken both on and off site are below 1 pCi/g, wet weight.

Figure 6-3 presents the 10-year trend of on-site and near off-site Cs-137 averages in deer meat. While similar in number to the samples taken in 2008, samples from 2014 indicate a narrower range of error and a significantly lower average. The 2014 average is approximately 3 times lower than the 2008 average and is 60 percent higher than the 2012 average, which had been the lowest average seen since trending began in 2000. These sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the

trend being downward from 2005 to 2014.

The effectiveness of the clean-up on Cs-137 in deer meat was evaluated and published in the scientific literature (Rispoli, et. al 2014). The average Cs-137 content was shown to be statistically lower than before clean-up. Samples taken at distances greater than 1 mile from the BNL site were shown to remain consistent before and after clean-up, while the on-site and near off-site values were shown to decline. In preparing for monitoring associated with the planned reduction of the deer population, the ten-year average for on-site deer samples was calculated to be at 1.0 pCi/g, wet weight.

When possible, liver samples are taken concurrently with meat samples. The liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2014, Cs-137 concentrations ranged from non-detect to 0.52pCi/g, wet weight, with an average of 0.27 pCi/g, wet weight. The off-site Cs-137 concentration in liver ranged from non-detect to 1.07 pCi/g, wet weight, with an arithmetic average for off-site liver samples within 1 mile of 0.31 pCi/g, wet weight, and a combined on-site and within 1 mile average of 0.58 pCi/g, wet weight. Liver samples from deer taken greater than one mile from BNL ranged from 0.05 to 0.31 pCi/g, wet weight, with an average of 0.12 pCi/g, wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer, and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most

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Table 6-2. Radiological Analyses of Deer Tissue.

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL, On Site				
Building 913, south	06/11/14	Flesh	2.9±0.27	0.02±0.01
		Liver	1.71±0.24	ND
South of Building 650	10/06/14	Flesh	3.18±0.33	0.02±0.01
		Liver	1.96±0.34	ND
Upton Road, 50 feet south of Bell Avenue	10/23/14	Flesh	3.57±0.26	0.59±0.03
		Liver	2.45±0.29	0.46±0.03
Brookhaven Avenue near LISF gate	10/31/14	Flesh	2.99±0.30	1.46±0.05
		Liver	1.62±0.40	0.52±0.05
West Princeton Avenue at motorpool	12/02/14	Flesh	2.84±0.35	0.92±0.05
		Liver	2.6±0.32	0.35±0.03
< 1 Mile from BNL				
William Floyd Parkway, south of north gate	03/24/14	Flesh	2.56±0.21	ND
		Liver	2.44±0.20	ND
William Floyd Parkway at north gate	05/21/14	Flesh	2.83±0.28	0.16±0.02
		Liver	2.55±0.38	0.05±0.02
Long Island Expressway at south gate	08/12/14	Flesh	3.34±0.44	0.39±0.04
		Liver	2.76±0.27	0.19±0.02
William Floyd Parkway at north gate	09/24/14	Flesh	3.22±0.22	1.93±0.04
		Liver	2.68±0.22	1.07±0.03
William Floyd Parkway, 1/4 mile south of main gate	10/27/14	Flesh	2.81±0.34	0.30±0.03
		Liver	2.39±0.30	0.22±0.03
> 1 Mile from BNL				
Route 21 at Cathedral Pines	03/19/14	Flesh	2.91±0.24	0.18±0.02
		Liver	2.26±0.24	0.05±0.01
Route 25 and Artist Drive	03/27/14	Flesh	2.35±0.34	0.10±0.02
		Liver	2.84±0.41	0.07±0.02
William Floyd Parkway, 1/2 mile south of Route 25A	06/19/14	Flesh	3.6±0.36	0.29±0.03
		Liver	2.75±0.31	0.10±0.02
Route 25 at Union Cemetery	10/16/14	Flesh	3.44±0.44	0.35±0.04
		Liver	2.62±0.53	0.31± 0.05
Mastic Beach Biltmore Drive at Wavecrest Drive	11/01/14	Flesh	2.87±0.29	0.13±0.02
		Liver	3.19±0.52	0.06±0.02
Route 25 at St. Francis Cabrini Church, Coram	11/13/14	Flesh	2.94±0.38	0.33±0.04
		Liver	2.25±0.31	0.06±0.02
Averages by Tissue				
Flesh Averages				
All Samples (18)			3.03±1.37	0.46±0.13
BNL Average (5)			3.10±0.68	0.60±0.08
< 1 Mile Average (5)			2.95±0.69	0.56±0.07
BNL + < 1 Mile Average (10)			3.02±0.97	0.58±0.10
> 1 Mile Average (8)			3.04±0.96	0.32±0.08
Liver Averages				
All Samples (18)			2.37±1.44	0.21±0.11
BNL Average (5)			2.07±0.72	0.27±0.07
< 1 Mile Average (5)			2.56±0.63	0.31±0.05
BNL + < 1 Mile Average (10)			2.32±0.96	0.29±0.09
> 1 Mile Average (8)			2.44±1.07	0.12±0.07

Notes:

All averages are the arithmetic average with confidence limits using a 2 sigma (95%) propagated error.

All values are shown with a 95% confidence interval.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

ND = not detected

radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g, wet weight, reported in 1996) would carry a total amount of approximately 0.2 μ Ci. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the IAEA threshold. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137. In 2014, two geese were sampled. A sample of the breast meat from each goose was sent for analysis, with values of non-detect for Cs-137 received for both samples.

6.3.3 Fish Sampling

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Monitoring of the river is conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring occurs during even-numbered years and post-cleanup monitoring occurs in odd-numbered years. Therefore, data presented for 2014 consists of surveillance monitoring of fish from the Peconic River locations, as well as background monitoring of fish from Lower Lake on the Carmans River.

Samples collected on site were from Area A of the Peconic River just downstream of the Sewage Treatment Plant (STP) outfall and Area D near the east boundary of the Laboratory. Various species of fish were also collected off site from Shultz Road, Donahue's Pond, and Lower Lake on the Carmans River (see Figure 5-7 for sampling stations). Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out under a permit from NYSDEC.

6.3.3.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2014 included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*). The edible (fillet) content of each fish were collected for analysis. Gamma spectroscopy analysis was performed on all samples. When fish samples were not of sufficient volume to conduct all non-radiological and radiological analyses, samples of the same species were composited. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations, and information on the naturally occurring radioisotope K-40 is included as a comparison.

Cs-137 was measured at levels ranging from non-detected to 0.18 pCi/g, wet weight, from the Peconic River system, and all samples from the Carmans River had non-detectable levels. Detectable Cs-137 levels in fish ranged from an estimated 0.08 pCi/g to 0.11 pCi/g, wet weight, in both largemouth bass and brown bullhead taken from Donahue's Pond to an estimated 0.18 pCi/g, wet weight, in a composite sample of largemouth bass taken from Area A. For comparison, the highest recent value of Cs-137 was 0.78 pCi/g, wet weight, in a composite sample of bluegill (*Lepomis macrochirus*) taken from Forge Pond in 2011.

To account for the different feeding habits and weights of various species, it is important to compare Cs-137 concentrations and other contaminants in species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders). Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.16 pCi/g, wet weight. Largemouth bass, the top predator from the Peconic River, showed Cs-137 levels of 0.18 pCi/g, wet weight, or less. Levels of Cs-137 in all fish species appear to be declining, compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations

Figure 6-2. Comparison of Cs-137 Average Concentrations in Deer Meat, 2014.

Figure 6-3. Ten-Year Trend of Cs-137 Concentrations in Deer Meat.

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	K-40	Cs-137
	pCi/g Wet Weight	
BNL, Area A		
Brown bullhead (composite)*	3.79 ± 0.46	0.11 ± 0.03
Brown bullhead (composite)*	3.15 ± 0.32	0.13 ± 0.02
Brown bullhead (composite)*	2.58 ± 0.57	0.12 ± 0.04
Brown bullhead (composite)*	3.16 ± 0.78	0.16 ± 0.05
Chain pickerel (composite)	No Data	No Data
Largemouth bass (composite)*	3.65 ± 0.40	0.18 ± 0.03
Pumpkinseed (composite)*	3.06 ± 0.55	0.12 ± 0.03
Pumpkinseed (composite)*	2.70 ± 0.90	0.12 ± 0.05
Pumpkinseed (composite)*	2.94 ± 0.89	0.15 ± 0.08
Donahue's Pond		
Brown bullhead*	2.41 ± 0.66	0.08 ± 0.04
Brown bullhead	2.62 ± 1.43	ND
Largemouth bass*	3.64 ± 0.87	0.08 ± 0.06
Largemouth bass*	3.19 ± 1.04	0.08 ± 0.06
Largemouth bass*	3.09 ± 0.739	0.11 ± 0.06
Lower Lake		
Bluegill	3.53 ± 0.86	ND
Bluegill (composite)	3.28 ± 0.81	ND
Bluegill (composite)	2.56 ± 0.56	ND
Brown bullhead	2.94 ± 0.60	ND
Brown bullhead	3.38 ± 0.71	ND
Brown bullhead	3.08 ± 0.75	ND
Brown bullhead	2.84 ± 0.66	ND
Brown bullhead (composite)	2.78 ± 0.69	ND
Largemouth bass	2.44 ± 0.97	ND
Largemouth bass	No Data	No Data
Pumpkinseed	No Data	No Data

Notes:

All samples analyzed as edible portions (fillets), including composite samples.

All values shown with a 95% confidence interval.

K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

* = estimated value for Cs-137 based on lab qualifiers

Cs-137 = cesium-137

K-40 = potassium-40

No Data = insufficient sample size to complete analysis

ND = not detected based on lab qualifiers

have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides were released between the late 1950s and early 1970s. Concentrations continue to decline over time by natural radioactive decay. Cs-137 has a half-life of 30 years. Discharge monitoring has demonstrated that no Cs-137 was released from the STP to the Peconic River during 2003 through 2014. Discharges from the STP to the Peconic River stopped in October 2014. Additionally, the cleanup of both on- and off-site portions of the Peconic River is estimated to have removed approximately 88 percent of the identified Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in continued decreases in Cs-137 levels in fish.

6.3.3.2 Fish Population Assessment

The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events are made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2014, even with low water levels in the on-site portion of the Peconic River, indicated that populations are maintaining themselves and can continue to support annual sampling efforts. With the termination of discharges to the Peconic River, on-site fish populations may decline and the need for monitoring will be evaluated.

6.3.3.3 Non-Radiological Analysis of Fish

Beginning in 2005, all fish of sufficient size have been analyzed as edible portions (fillets). Due to its known health effects, mercury is the metal of highest concern. Monitoring results for 2014 surveillance monitoring of the Peconic River and comparison to Lower Lake on the Carmans River is shown in Table 6-4. All samples were obtained between April and mid-June. During 2014, mercury ranged from 0.18 mg/kg in a composite of brown bullhead to 0.73 mg/kg in a composite sample of largemouth bass in Area A, and from less than the

minimum detection level (MDL) in a brown bullhead to 0.62 mg/kg in a largemouth bass at Donahue's Pond. Mercury in control fish taken from Lower Lake on the Carmans River ranged from less than the MDL in bluegill, pumpkinseed, brown bullhead, and largemouth bass to 0.15 mg/kg in a brown bullhead.

Monitoring data for mercury analysis in fish is presented as a range of results by species and location in Table 6-5 and utilizes the data regardless of whether or not it fell below MDLs in order to facilitate comparisons. The data are presented graphically in Figure 6-4. Data are typically compared to the EPA mercury water criterion of 0.3 mg/kg. Mercury values in on-site fish taken from Area A during 2014 are similar those seen in 2013 but higher than those seen in 2011 and 2012. This increase is most likely due to low water flow conditions in the river since late summer 2011, with limited open water areas and little or no flow off site. Consequently, fish have been isolated to the BNL site and any methylated mercury was not diluted by flow. Mercury content in fish between on site locations and off site locations indicate that concentrations decrease significantly once off site, and values at Donahue's Pond are similar to those from Lower Lake on the Carmans River.

Fish are also monitored for a variety of other metals during surveillance monitoring years. The analytical results for metals of concern are also presented in Table 6-4. None of the metals were above levels of concern, and are similar to values seen historically. On site fish are monitored for PCBs due to their historical use at BNL. Table 6-6 shows the results for PCBs from fish taken from Area A on site. Fillets are analyzed for PCBs after metals and radionuclides. Due to lack of sufficient sample volume, some samples had no PCB analysis. Only two PCB congeners were detected; Aroclor-1254 and Aroclor-1260; most values were below the MDL. Both Aroclor-1254 and Aroclor-1260 were detected in brown bullhead and largemouth bass above the MDL, and Aroclor-1254 was also detected in a sample from pumpkinseed. The highest concentration of Aroclor-1254 was 55.1 µg/kg

in brown bullhead, and the highest concentration of Aroclor-1260 was 35.7 µg/kg found in the same sample. These levels are compared to the Food and Drug Administration tolerance levels of 2 ppm in edible portions of fish in the commercial food supply.

6.3.4 Aquatic Sampling

6.3.4.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River was conducted in 2014. (See Chapter 5 for a discussion on water quality and monitoring and Figure 5-7 for the locations of sampling stations.) During 2014, Cs-137 was detected in a single aquatic vegetation sample at an estimated concentration of 0.03 pCi/g, wet weight, as shown in Table 6-7.

6.3.5 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of the Peconic River were remediated in 2004 and 2005 to remove sediments contaminated with mercury and associated contaminants. To ensure that the cleanup provided adequate protection of human health and the environment, BNL conducted five years (2006-2010) of post-cleanup monitoring of the sediment, surface water, and fish. This monitoring effort identified approximately 0.39 acres in three small areas (PR-WC-06, PR-SS-15, and sediment trap areas) with mercury concentrations greater than the cleanup goal of 2.0 mg/kg. The three areas were remediated between November 2010 and February 2011 (see Section 6.3.5.1).

During the required CERCLA Five-Year review process in 2011, all data and accomplishments related to the Peconic River cleanup and subsequent monitoring were summarized and reviewed (BNL 2011). The Five-Year Review recommended that reduced monitoring should take place beginning in 2012. The reductions included decreasing sediment sampling to just the three areas associated with the supplemental cleanup; water monitoring was reduced from 30 locations to the current 14, and fish monitoring was to alternate years with the surveillance monitoring. The 2014 sediment and surface water results follow.

Table 6-4. Metals Analysis of Fish from the Peconic River and Lower Lake, Carmans River.

Location/Species	Barium	Chromium	Copper	Manganese	Mercury	Nickel	Zinc
BNL, Area A	----- mg/kg -----						
Brown bullhead (composite)	0.11	< MDL	< MDL	< MDL	0.181	< MDL	6.11
Brown bullhead (composite)	0.254	< MDL	0.851	< MDL	0.222	< MDL	11.2
Brown bullhead (composite)	0.234	< MDL	< MDL	0.208	0.348	< MDL	8.5
Brown bullhead (composite)	0.312	< MDL	0.691	0.196	0.28	< MDL	13.4
Chain pickerel (composite)	0.3	< MDL	0.558	0.385	0.189	< MDL	10.6
Largemouth bass (composite)	< MDL	< MDL	< MDL	< MDL	0.732	< MDL	6.55
Pumpkinseed (composite)	< MDL	< MDL	< MDL	< MDL	0.458	< MDL	8.74
Pumpkinseed (composite)	0.256	< MDL	< MDL	< MDL	0.446	< MDL	9.66
Pumpkinseed (composite)	0.266	< MDL	< MDL	< MDL	0.415	< MDL	8.54
Donahue's Pond							
Brown bullhead	1.16	< MDL	0.475	1.66	< MDL	< MDL	6.67
Brown bullhead	0.468	0.349	0.797	< MDL	0.123	< MDL	12.2
Largemouth bass	0.643	0.44	< MDL	1.03	< MDL	< MDL	26.9
Largemouth bass	0.775	0.245	< MDL	2.42	< MDL	< MDL	11
Largemouth bass	1.06	0.147	< MDL	0.721	0.616	< MDL	7.74
Lower Lake							
Bluegill	2.21	< MDL	< MDL	5.24	< MDL	< MDL	13.4
Bluegill (composite)	< MDL	< MDL	< MDL	0.211	< MDL	0.135	5.31
Bluegill (composite)	2.57	0.18	< MDL	3.97	< MDL	< MDL	13.6
Brown bullhead	0.26	0.152	0.291	0.509	< MDL	< MDL	6.53
Brown bullhead	0.225	< MDL	0.328	0.187	< MDL	0.19	9.97
Brown bullhead	0.166	< MDL	0.307	< MDL	0.152	< MDL	6.9
Brown bullhead	0.242	< MDL	< MDL	< MDL	< MDL	0.341	5.91
Brown bullhead (composite)	0.237	< MDL	0.281	< MDL	< MDL	0.184	6.6
Largemouth bass	0.153	< MDL	< MDL	0.188	< MDL	0.156	8.65
Largemouth bass	0.614	< MDL	< MDL	0.51	0.103	< MDL	17.3
Pumpkinseed	1.11	< MDL	< MDL	2.73	< MDL	< MDL	14.8

Notes:

See Figure 5-4 for sampling locations.

All samples were analyzed as edible portions (fillets), including composite samples.

Area letter designation refers to Peconic River cleanup areas on site.

MDL = minimum detection limit

6.3.5.1 Sediment Sampling

Sediment was sampled in June 2014 at three Peconic River locations associated with the supplemental cleanup areas remediated during 2010 and 2011 (see Table 6-7). Radiological analysis of sediments at all three locations indicate that low levels of Cs-137 are present, ranging from 0.32 pCi/g to 5.49 pCi/g, which are consistent with previous analyses of the river sediments. Analysis of sediment for

mercury identified values ranging from 0.33 mg/kg to 7.40 mg/kg. The 7.40 mg/kg value was from a sample taken at the PR-WC-06 area, and was above the 2.0 mg/kg clean-up goal. This result, along with the fact that concentrations above 2.0 mg/kg were seen at this location in the past, resulted in an effort to determine the extent of mercury in sediment around this point. Additional samples were taken late in 2014 within two locations,

Figure 6-4. Peconic River and Lower Lake, Carmans River Mercury Distribution in Fish Species (Minimum, Maximum, and Average Values).

one upstream and one downstream, with values above 2.0 mg/kg. Additional sampling is planned for 2015.

6.3.5.2 Water Column Sampling

Surface water was analyzed in June and July 2014 for total mercury and methyl mercury at 6 of the 14 Peconic River sampling stations (see Table 6-8). Water column sampling locations are shown on Figure 6.5. A sample of the treated STP effluent was also collected during each round of sampling. Eight stations could not be sampled in both June and July due to either being too shallow or dry. Total Suspended Solids (TSS) are reported in Table 6-8 because TSS values can provide an indication of the quality of the sample collection effort. Low TSS indicates a sample was taken without disturbing bottom sediments, whereas samples with high TSS values might explain, in part, unusually high mercury values due to increased particles that may contain mercury.

The maximum total mercury concentration in the June (30 ng/L) and July (32 ng/L) STP effluent samples were typical of what has been seen since efforts at mercury minimization have been implemented. The total mercury concentrations generally trended downwards, with minor fluctuations at increasing distance downstream from the STP, until reaching concentrations of 19 ng/L (June 2014) and 17 ng/L (July 2014) at sampling stations near Shultz Road, approximately 2.1 miles downstream of the STP outfall. One sample taken in July from PR-WC-06 had a mercury value of 140 ng/L, which was likely due to high amounts of sediment entrained in the sample as evidenced by the high TSS value of 41 mg/L.

Methyl mercury is the form of mercury that is bio-available to aquatic organisms. Methyl mercury was not detected in STP effluent samples in June and at a concentration of 0.11 ng/L in the July sample. Methyl mercury was measured at 5 monitoring stations in both June and July. In

Table 6-5. Mercury Analysis of Fish from the Peconic River System and Lower Lake, Carmans River.

Location/Species (number of samples)	Mercury mg/kg		
	Min.	Max.	Avg.
BNL, Area A			
Brown bullhead (4)*	0.181	0.348	0.258
Chain pickerel (1)*	0.189	0.189	0.189
Largemouth bass (1)*	0.732	0.732	0.732
Pumpkinseed (3)*	0.415	0.458	0.44
Donahue's Pond			
Brown bullhead (2)	0.0773	0.123	0.1
Largemouth bass (3)	0.074	0.616	0.256
Lower Lake, Carmans River			
Bluegill (3)*	0.075	0.08	0.078
Brown bullhead (5)*	0.071	0.152	0.089
Largemouth bass (2)	0.075	0.103	0.089
Pumpkinseed (1)	0.078	0.078	0.078

Notes:

See Figure 5-4 for sampling locations.

All samples were analyzed as edible portions (fillets), including composite samples.

Area letter designation refers to Peconic River cleanup areas on site.

* = one or more samples in the average were composite samples.

June, methyl mercury ranged from 5.1 ng/L at the station immediately upstream of the STP effluent outfall to 0.66 ng/L at the station approximately 0.3 miles below the outfall. Values then increased on site to Area D, and then declined to 0.77 ng/L at a distance of 2.1 miles from the outfall. A similar pattern was seen in methyl mercury concentrations in July samples with the farthest downstream detection being roughly twice the value of the June sample.

6.3.6 Vegetation Sampling

6.3.6.1 Grassy Plants and Soil

Grassy vegetation sampling around the Laboratory was conducted in 2014. Vegetation was sampled from 12 random locations, as shown in Figure 6-6. All samples were analyzed for Cs-137 (Table 6-9). All but one of the grassy vegetation samples had non-detectable levels of Cs-137. The single sample with a detectable level had a concentration of 0.03 pCi/g, wet weight, which is consistent with past sampling efforts. Monitoring results for grassy vegetation

Table 6-6. PCB Analysis of Fish from BNL Portions of the Peconic River System.

Location/Species	Aroclor-1254	Aroclor-1260
	_____ μg/kg _____	
BNL, Area A		
Brown bullhead (composite)	< MDL	< MDL
Brown bullhead (composite)	55.1	35.7
Brown bullhead (composite)	53.4	31.2
Brown bullhead (composite)	No Data	No Data
Chain pickerel (composite)	No Data	No Data
Largemouth bass (composite)*	13.9	9.93
Pumpkinseed (composite)*	10.5	< MDL
Pumpkinseed (composite)	No Data	No Data
Pumpkinseed (composite)	No Data	No Data

Notes:

All samples were analyzed as edible portions (fillets), including composite samples.

* = estimated value for reported analyte based on lab qualifiers

MDL = minimum detection limit

No Data = insufficient sample size to complete analysis

is utilized for the annual dose to biota analysis reported in Chapter 8.

Soil sampling was conducted at the same 12 locations where the grassy vegetation was collected. Soil samples were analyzed for Cs-137 (Table 6-9). Cs-137 concentrations in soils ranged from non-detect to 0.44 pCi/g, dry weight. These values were consistent with past soil monitoring results.

6.4 OTHER MONITORING

6.4.1 Basin Sediments

A five-year cycle for the collection of recharge basin sediment samples was established in 2003. There are 11 recharge basins that receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-5 for outfall locations). Basin sediments were last sampled in 2012 and results were summarized in the 2012 Site Environmental Report (BNL, 2013b). The next round of routine basin sampling will be conducted in 2017.

6.4.2 Chronic Toxicity Tests

Under BNL's SPDES discharge permit, the Laboratory conducted chronic toxicity testing

Table 6-7. Surveillance and Post Cleanup Monitoring Data for Aquatic Vegetation and Sediment from the Peconic River.

Location	Matrix	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Mercury mg/kg
Surveillance Samples				
BNL	Vegetation	3.70 ± 0.41	ND	NT
BNL	Vegetation	2.66 ± 0.35	ND	NT
BNL*	Vegetation	5.78 ± 0.49	0.03 ± 0.02	NT
BNL	Vegetation	3.91 ± 0.44	ND	NT
Post-Cleanup Samples				
PR-WC-06-D1-L50	Sediment	NT	5.49 ± 0.68	7.40
PR-WC-06-D1-L50-01	Sediment	NT	NT	3.30
PR-WC-06-D1-L50-02	Sediment	NT	NT	0.38
PR-WC-06-D1-L50-03	Sediment	NT	NT	0.97
PR-WC-06-D1-L50-04	Sediment	NT	NT	5.60
ST1-80-U20	Sediment	NT	1.56 ± 0.22	0.50
PR-SS-15-U1-L65-O	Sediment	NT	0.32 ± 0.07	0.33

Notes:

All values are shown with a 95% confidence interval.

Radiological values for sediment are reported as dry weight.

K-40 Occurs naturally in the environment and is presented as a comparison to Cs-137.

* = values for Cs-137 are estimated based on analytical lab qualifiers

Cs-137 = cesium-137

K-40 = potassium-40

ND = not detected

NT = not tested

of the STP effluent. The results of the chronic toxicity tests are discussed in Chapter 3, Section 3.6.1.1. Because the Laboratory discontinued discharging STP effluent to the Peconic River in October 2014, chronic toxicity testing will no longer be required under the new SPDES discharge permit.

6.4.3 Radiological and Mercury Monitoring of Precipitation

During 2014, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations). The samples were analyzed for radiological content and total mercury. Gross alpha activity measurements were above the MDL at P4 in the first three quarters and in the first and third quarters at S5 (Table 6-10).

Gross beta activity was measured in samples collected during all four quarters, at monitoring stations P4 and S5. Location P4 had a maximum

gross beta activity level of 3.13 pCi/L in the fourth quarter of 2014. Location S5 had a maximum gross beta activity level of 6.30 pCi/L in the first quarter. Gross beta, gamma, and Sr-90 activity values were within the range of historically observed values at these two locations.

Mercury concentrations in precipitation have been measured at BNL since 2007. Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River watershed. Mercury was detected in all of the precipitation samples collected at both sampling stations. During 2014, mercury ranged from 2.24 ng/L at station P4 in October to 7.32 ng/L at station P4 in July. This range is one twelfth to one third of the highest value measured in precipitation, 24.6 ng/L, detected in 2013.

Table 6-8. Post Cleanup Peconic River Water Column Monitoring.

Location	Station Description	Dist from STP (miles)	June 2014			July 2014		
			Mercury ng/L	Methyl Mercury ng/L	TSS mg/L	Mercury ng/L	Methyl Mercury ng/L	TSS mg/L
PR-WC-15	Upstream of Forest Path	-0.17	SW	SW	SW	SW	SW	SW
PR-WC-14	Upstream of STP	-0.13	SW	SW	SW	SW	SW	SW
PR-WC-13	Upstream of STP	-0.07	SW	SW	SW	SW	SW	SW
PR-WC-12-D7	Downstream of Sump	-0.04	7.2	5.1	6	2	1.4	ND
STP-EFF-UVG	Grab Sample	0	30	ND	ND	32	0.11	ND
PR-WC-11DS	50 feet downstream of outfall	0.01	SW	SW	SW	SW	SW	SW
PR-WC-10	West of HMN	0.3	27	0.66	2	48	.41	ND
PR-WC-09	Downstream of HMN	0.56	SW	SW	SW	SW	SW	SW
PR-WC-08	South of Area B	0.78	24	1.6	10	35	1.3	3
PR-WC-07	South of Area C	0.96	SW	SW	SW	SW	SW	SW
PR-WC-06	South of Area D*	1.1	17	3.2	50	140	1.8	41
PR-WC-05	Downstream of HQ	1.46	SW	SW	SW	SW	SW	SW
PR-WC-04	2nd downstream of HQ	1.7	SW	SW	SW	SW	SW	SW
PR-WC-03	3rd west of Schultz Road	2.1	19	0.77	9	17	1.4	16
PR-WC-02	2nd west of Schultz Road	2.52	SW	SW	SW	SW	SW	SW

Notes:

See Figure 6-5 for Peconic River sampling locations.

ND = not detected based on lab qualifiers

STP = Sewage Treatment Plant

SW = water too shallow to sample

* = estimated value based on lab qualifiers

6.5 WILDLIFE PROGRAMS

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster an interest in science. Wildlife programs are conducted at the Laboratory in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2014, BNL hosted 15 student interns and one faculty member. Two of the interns worked with a faculty member from Dowling College as part of the BNL Visiting Faculty Program (VFP), and 13 interns participated in research associated with various projects including several related to the LISF. The Natural Resource program typically supports two interns in the

spring, three in the fall, and the remainder participating in the summer internship program.

The VFP team continued ongoing work on statistical analysis of migratory bird data and data associated with Cs-137 in deer. The Cs-137 in deer work was published in October 2014 and discussed the effectiveness of environmental cleanup with regard to the uptake of Cs-137 by deer (Rispoli, et. al., 2014).

Work associated with the LISF involved tracking 24 eastern box turtles outfitted with transmitters to determine home range sizes. Many of the turtles were captured in or near the LISF in order to determine if they utilize habitats found in the facility. Since 2011, student interns have followed a total of 40 different turtles; as a result, BNL is building a very good understanding of their habits. Turtles are also permanently marked to facilitate identification of individual turtles as part of a mark

Figure 6-5. Peconic River Sample Locations, 2014.

Figure 6-6. Vegetation Sample Locations, 2014.

Table 6-9. Radiological Analysis of Grassy Vegetation and Associated Soils (2014).

Location/Matrix	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
Meteorology Field		
Vegetation	3.79 ± 0.47	ND
Soil	9.54 ± 0.56	0.13 ± 0.39
West End of Brookhaven Avenue		
Vegetation	2.77 ± 0.40	0.03 ± 0.02
Soil	6.00 ± 0.71	0.44 ± 0.06
Field south of HT-E		
Vegetation	6.16 ± 0.63	ND
Soil	5.73 ± 0.70	0.11 ± 0.04
RHIC Berm at 6 o'clock		
Vegetation	ND	ND
Soil	4.76 ± 0.51	0.08 ± 0.03
RHIC Berm at 8 o'clock		
Vegetation	3.53 ± 0.61	ND
Soil	4.76 ± 0.51	0.08 ± 0.03
RHIC Berm at 10 o'clock		
Vegetation	2.27 ± 0.58	ND
Soil	3.95 ± 0.50	0.07 ± 0.04
Southwest Corner HWMF, outside fence		
Vegetation	3.37 ± 0.62	ND
Soil	5.97 ± 0.68	0.23 ± 0.05
Booster Berm NSLS-II		
Vegetation	3.39 ± 0.61	0.04 ± 0.02
Soil	6.36 ± 0.52	0.19 ± 0.03
NSLS-II BERM		
Vegetation	3.58 ± 0.52	ND
Soil	5.54 ± 0.52	0.16 ± 0.04
Former Landfill		
Vegetation	4.31 ± 0.58	ND
Soil	5.76 ± 0.55	0.14 ± 0.04
HM-N		
Vegetation	4.16 ± 0.52	ND
Soil	4.64 ± 0.45	0.04 ± 0.02
P7 Air Station		
Vegetation	5.15 ± 0.69	ND
Soil	8.47 ± 0.65	ND

Notes:
 All values are shown with a 95% confidence interval.
 Radiological values for soils are reported on a "dry weight" basis.
 K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
 Cs-137 = cesium-137
 HWMF = Hazardous Waste Management Facility
 k-40 = potassium-40
 ND = not detected
 NSLS-II = National Synchrotron Light Source II
 RHIC = Relativistic Heavy Ion Collider

Table 6-10. Precipitation Monitoring (Radiological and Mercury).

Location/Matrix	Gross Alpha pCi/g	Gross Beta pCi/g	Mercury ng/L
P4			
01/15/04	-	-	6.11
01/31/14	3.35 ± 1.19	2.61 ± 0.89	-
04/09/14	-	-	5
04/30/14	2.17 ± 1.18	2.26 ± 0.80	-
07/16/14	-	-	7.32
07/31/14	3.35 ± 1.29	2.52 ± 0.86	-
10/06/14	-	-	2.24
11/26/14	ND	3.13 ± 0.87	-
S5			
01/15/04	-	-	6.28
01/31/14	4.81 ± 1.48	6.30 ± 1.22	-
04/09/14	-	-	6.22
04/30/14	ND	2.36 ± 0.77	-
07/16/14	-	-	4.98
07/31/14	1.95 ± 1.13	1.82 ± 0.75	-
10/06/14	-	-	2.66
11/26/14	ND	3.46 ± 0.88	-

Notes:
 All values are shown with a 95% confidence interval.
 K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
 AGS = Alternate Gradient Synchrotron
 Cs-137 = cesium-137
 K-40 = potassium-40
 ND = not detected
 * = value for Cs-137 is estimated

recapture effort. Several turtles marked in early 2000 have been recaptured 10 years later, providing a snapshot into longevity and movement in turtles.

Interns also conducted surveys in and around the LISF to study the relationship and impacts of this facility on the local ecosystems. Vegetation data were gathered on paired transects during the summer and fall, and paired small mammal trapping grids and moveable cameras were used to look at how animals used the fence openings. Paired trapping grids were established to compare small mammal population in the core of the facility to core habitats outside of the facility, and to compare recruitment of small mammals from the forest to the immediate interior of the solar farm (one grid on either side of the LISF fence). The camera

surveillance data verified that all species that were expected to use the openings are doing so (e.g., raccoons, skunks, foxes, etc.). Paired transects for vegetation allow comparison of vegetation growth and establishment inside and outside of the LISF. In addition, interior transects were established based on the vegetative assemblage that existed prior to construction.

To facilitate the analysis of the wildlife surveillance data and to develop plans for the placement of transects, trapping grids, and placement of cameras, all surveillance data are entered into databases, and a GIS is used to visualize the data.

In March 2011, a northern long-eared bat (*Myotis septentrionalis*) was found on the ground outside a building on site. The bat appeared to have discoloration on the fur around its muzzle and was reported to NYSDEC as a possible incidence of white-nose syndrome. White-nose syndrome is a recently identified fungal infection impacting bats throughout the Northeast and Midwest. The bat was the first recorded incidence of white-nose syndrome on Long Island. As a result, BNL and NYSDEC established permanent acoustical survey routes on Long Island for monitoring. In 2014, a bat specialist captured bats on site using mist-netting. These results were compared to 2012 and 2013 efforts, and confirmed that white-nosed syndrome has had a major impact on certain bat species, particularly the northern long-eared bat which showed a dramatic reduction in population at BNL based upon 15 captures in 2012 to only one capture in 2013. However, captured ‘young of the year’ in 2014 suggest that there is potential for the population to survive, even if at low population densities. Additional work on the northern long-eared bat needs to be completed to facilitate recovery plans for this soon to be listed species.

In 2014, BNL continued to participate in several events in support of ecological education programs including: providing on-site ecology tours; hosting the Nineteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results; participated in the Fifth Annual Pine Barrens Discovery Day held in association with

the Tri-Hamlet Celebration at the Wertheim National Wildlife Refuge; and assisting the Central Pine Barrens Commission on “A Day in the Life of the Rivers,” which allowed students from multiple school districts to acquire environmental and biological data about the Carmans, Peconic, and Nissequogue Rivers.

The Laboratory also hosted the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. Using the Incident Command System of wildfire management, this academy trains firefighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. The Laboratory continues the use of prescribed fire for fuel and forest management and is working with NYSDEC to conduct growing season fires in northern and eastern sections of the BNL property. A growing season prescribed fire was planned to take place in June 2014; however, due to last minute changes in meteorological conditions, the planned fire was suspended. Because the team was already assembled for the prescribe fire, the action was changed to a training exercise to improve fire line hose lays and use of new techniques in wildland fire and prescribed fire management.

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL 2013a) guides the management of all of the Laboratory’s historical resources. BNL’s cultural resources include buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to our history and culture are documented and available for interpretation.

The Laboratory has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the WWI training trenches associated with Camp Upton. The trenches are examples of the few surviving WWI earthworks in the United States.

In 2014, BNL submitted a Section 106 review concerning the planned demolition of four structures on site to the New York State Historic Preservation Office (NYSHPO) for review as required under the National Historic Preservation Act. Although the four buildings were auxiliary support structures associated with the early history of BNL, they were determined not to have played a significant contribution. The NYSHPO requested additional analysis in order to provide concurrence with the finding.

The Laboratory loaned the Long Island History Museum materials from the Camp Upton Collection covering both World War I and WW II for their display on “Long Island at War.” The loan of materials and display were described in a BNL website in an article titled ‘Long Island at War: Camp Upton Artifacts on Display at Long Island Museum.’ A small display on Camp Upton is continually maintained at the Laboratory’s cafeteria and conference center, Berkner Hall. The display is reviewed each year for changes before the Summer Sundays program starts in July. During 2014, the display was updated with new material, including a graphic map of WWI Camp Upton showing where major buildings were located, along with photos of those structures. As part of the outreach effort of the Cultural Resource Management program, a presentation on the ‘History of the BNL Site’ was developed and presented to BNL’s Community Advisory Council and a modified version focusing on the history of the site from a natural history perspective was presented at a meeting of the South Shore Audubon Society.

The Laboratory undergoes an annual external assessment as part of its ISO 14001 certification. During the 2014 assessment, the Cultural Resource Management program was evaluated. The Cultural Resource Management Plan contains a Standard Operating Procedure (SOP) for the tagging of cultural resource items. This SOP had not been implemented due to staffing issues. The assessment listed the finding as a non-conformance and corrective actions were required to ensure that the tagging program was implemented. An intern project was posted at C.W. Post Library Sciences department, and an intern was selected and scheduled to start on the project by year’s end.

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Groundwater Protection

Brookhaven National Laboratory has implemented aggressive pollution prevention measures to protect groundwater resources, and an extensive groundwater monitoring well network is used to verify that prevention and restoration activities are effective. During 2014, BNL collected groundwater samples from 756 permanent monitoring wells and 67 temporary wells during 1,737 individual sampling events. Ten groundwater remediation systems removed 143 pounds of volatile organic compounds (VOCs) and returned approximately 1.2 billion gallons of treated water to the Upper Glacial aquifer. Since the beginning of active groundwater remediation in December 1996, the treatment systems have removed 7,276 pounds of VOCs by treating nearly 23 billion gallons of groundwater. Also during 2014, two groundwater treatment systems removed approximately 1.2 millicuries of strontium-90 (Sr-90) while remediating approximately 13 million gallons of groundwater. Since 2003, BNL has removed approximately 30 millicuries of Sr-90 from the groundwater while remediating 143 million gallons of groundwater. As a result of the successful operation of these treatment systems, significant reductions in contaminant concentrations have been observed in a number of on- and off-site areas.

7.1 THE BNL GROUNDWATER PROTECTION MANAGEMENT PROGRAM

The primary goal of BNL's Groundwater Protection Program is to ensure that plans for groundwater protection, management, monitoring, and restoration are fully defined, integrated, and managed in a manner that is consistent with federal, state, and local regulations. The program helps to fulfill the environmental monitoring requirements outlined in various New York State operating permits, DOE Order 458.1, *Radiation Protection of the Public and Environment*, and DOE Order 436.1, *Departmental Sustainability*. This program also satisfies the monitoring and remediation requirements defined in Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Records of Decision (RODs). The program consists of four interconnecting elements: 1) preventing pollution of the groundwater, 2) monitoring the effectiveness of engineered and administrative controls at operating facilities, 3) restoring the environment by cleaning up contaminated soil and groundwater, and 4) communicating

with stakeholders on groundwater protection issues. The Laboratory is committed to protecting groundwater resources from further chemical and radionuclide releases, and to remediate existing contaminated groundwater.

7.1.1 Prevention

As part of BNL's Environmental Management System, the Laboratory has implemented a number of pollution prevention activities that are designed to protect groundwater resources (see Chapter 2). BNL has established a work control program that requires the assessment of all experiments and industrial operations to determine their potential impact on the environment. The program enables the Laboratory to integrate pollution prevention and waste minimization, resource conservation, and compliance into planning and decision making. Efforts have been implemented to achieve or maintain compliance with regulatory requirements and to implement best management practices designed to protect groundwater (see Chapter 3). Examples include

upgrading underground storage tanks, closing cesspools, adding engineered controls (e.g., barriers to prevent rainwater infiltration that could move contaminants out of the soil and into groundwater), and administrative controls (e.g., reducing the toxicity and volume of chemicals in use or storage). BNL's comprehensive groundwater monitoring program is used to confirm that these controls are working.

7.1.2 Monitoring

The Laboratory's groundwater monitoring network is designed to evaluate the impacts of groundwater contamination from former and current operations and to track cleanup progress. Each year, BNL collects groundwater samples from an extensive network of on- and off-site monitoring wells. Results from groundwater monitoring are used to verify that protection and restoration efforts are working. Groundwater monitoring is focused on two general areas: 1) Facility Monitoring, designed to satisfy DOE and New York State monitoring requirements for active research and support facilities, and 2) CERCLA monitoring related to the Laboratory's obligations under the Federal Facilities Agreement (FFA). These monitoring programs are coordinated to ensure completeness and to prevent duplication of effort in the installation, monitoring, and decommissioning of wells. The monitoring program elements include data quality objectives; plans and procedures; sampling and analysis; quality assurance; data management; and the installation, maintenance, and decommissioning of wells. These elements are integrated to create a cost-effective monitoring system and to ensure that water quality data are available for review and interpretation in a timely manner.

7.1.3 Restoration

BNL was added to the National Priorities List in 1989. To help manage the restoration effort, 32 separate Areas of Concern (AOC) were grouped into six Operable Units (OUs). Remedial actions have been implemented for each OU, and the focus is currently on operating and maintaining cleanup systems. Contaminant

sources (e.g., contaminated soil and underground storage tanks) have been removed or remediated to prevent further contamination of groundwater. All remediation work is carried out under the FFA involving EPA, the New York State Department of Environmental Conservation (NYSDEC), and DOE.

7.1.4 Communication

BNL's Stakeholder and Community Relations Office works with the Groundwater Protection Program to ensure that the Laboratory communicates groundwater protection issues and cleanup progress with its stakeholders in a consistent, timely, and accurate manner. A number of communication mechanisms are in place, such as press releases, web pages, mailings, public meetings, briefings, and roundtable discussions. Specific examples include routine meetings with the Community Advisory Council and the Brookhaven Executive Roundtable (see Chapter 2, Section 2.4.2). Quarterly and annual technical reports that summarize data, evaluations, and program indices are prepared. In addition, The Laboratory has developed a Groundwater Protection Contingency Plan (BNL 2013) that provides formal processes to promptly communicate off-normal or unusual monitoring results to BNL management, DOE, regulatory agencies, and other stakeholders, including the public and employees.

7.2 GROUNDWATER PROTECTION PERFORMANCE

BNL has made significant investments in environmental protection programs over the past 20 years and continues to make progress in achieving its goal of preventing new groundwater impacts and to remediate previously contaminated groundwater. No new impacts to groundwater quality were discovered during 2014. The Laboratory will continue efforts to prevent new groundwater impacts and is vigilant in measuring and communicating its performance.

7.3 GROUNDWATER MONITORING PROGRAMS

Elements of the groundwater monitoring program include installing monitoring wells; planning and scheduling; developing and following quality assurance procedures; collecting and

analyzing samples; verifying, validating, and interpreting data; and reporting. Monitoring wells are used to evaluate BNL's progress in restoring groundwater quality, to comply with regulatory permit requirements, to monitor active research and support facilities, and to assess the quality of groundwater that enters and exits the site.

The Laboratory monitors research and support facilities where there is a potential for environmental impact, as well as areas where past waste handling practices or accidental spills have already degraded groundwater quality. The groundwater beneath the site is classified by New York State as Class GA groundwater, which is defined as a source of potable water. Federal drinking water standards (DWS), New York State DWS, and New York State Ambient Water Quality Standards (NYS AWQS) for Class GA groundwater are used as goals for groundwater protection and remediation. BNL evaluates the potential impact of radiological and nonradiological contamination by comparing analytical results to the standards. Contaminant concentrations that are below the standards are also compared to background values to evaluate the potential effects of facility operations. The detection of even low concentrations of facility-specific volatile organic compounds (VOCs) or radionuclides may provide important early indications of a contaminant release and allow for timely identification and remediation of the source.

Groundwater quality at BNL is routinely monitored through a network of approximately 760 on- and off-site wells (see SER Volume II, Groundwater Status Report, for details). In addition to water quality assessments, water levels are routinely measured in 725 of the wells to assess variations in the direction and velocity of groundwater flow. Groundwater flow directions in the vicinity of the Laboratory are shown in Figure 7-1.

The following active BNL facilities have groundwater monitoring programs: the Sewage Treatment Plant (STP), Waste Management Facility (WMF), Major Petroleum Facility (MPF), Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source II (NSLS-II), and

several vehicle maintenance and petroleum storage facilities. Inactive facilities include the former Hazardous Waste Management Facility (HWMF), two former landfill areas, Waste Concentration Facility (WCF), Brookhaven Graphite Research Reactor (BGRR), High Flux Beam Reactor (HFBR), and the Brookhaven Medical Research Reactor (BMRR). Maps showing the main VOC and radionuclide plumes are provided as Figures 7-2 and 7-3, respectively.

7.4 GROUNDWATER MONITORING RESULTS

During 2014, the Facility Monitoring program monitored 125 wells during 223 individual sampling events. No new impacts to groundwater quality were discovered during the year. The CERCLA groundwater monitoring program monitored 631 monitoring wells during 1,514 individual groundwater sampling events. Sixty-seven temporary wells were also installed as part of this program. Detailed descriptions and maps related to the groundwater monitoring programs can be found in SER Volume II, Groundwater Status Report.

Highlights of the groundwater monitoring programs for 2014 include:

- Significant reductions in contaminant concentrations continue to be observed in a number of on- and off-site areas. As a result, the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, and the HFBR Tritium Pump and Recharge System were shut down 2013, and were in standby mode during 2014.
- Although the North Street Treatment System was placed in standby mode in 2013, the system was restarted in June 2014 due to a rebound in VOC concentrations above the cleanup goal in several monitoring wells.
- Monitoring results indicate that the North Street East Treatment System has met its cleanup objectives. Following regulatory agency approval of a Petition for Shutdown (BNL 2014), the system was placed in a standby mode in June 2014.
- Groundwater characterization work in the off-site Industrial Park area identified a

Figure 7-1. Groundwater Flow and Water Table Elevation (December 2014) with Supply and Remediation Wells Shown.

Figure 7-2. Extent of VOC Plumes.

Figure 7-3. Extent of Radionuclide Plumes.

deep zone of VOC contamination, with total VOC concentrations up to 268 µg/L. Because this deeper zone of contamination cannot be effectively remediated using the existing Industrial Park Treatment System, two deeper extraction wells were installed during 2014. The new extraction wells will begin operating in January 2015.

- Significant reductions in VOC concentrations have been observed in the Building 96 source area monitoring wells following the 2010 excavation of contaminated source area soils. In a monitoring well located immediately downgradient of the excavation, total VOC concentrations decreased from a maximum of 2,435 µg/L in early 2011, to less than 200 µg/L in late 2014.
- During 2012 through 2014, approximately 96 pounds of Freon-11 were removed from the aquifer, and significant reductions in Freon-11 concentrations were observed in the Building 452 source area and downgradient portions of the plume. Freon-11 concentrations in groundwater have decreased from a maximum concentration of 38,000 µg/L when the plume was discovered in 2011, to less than 77 µg/L in late 2014.
- Although Sr-90 concentrations in the groundwater immediately downgradient of the BGRR had decreased to less than 10 pCi/L by the end of 2012, Sr-90 levels increased to as high as 487 pCi/L in 2013. During 2014, Sr-90 levels decreased to less than 5 pCi/L. It is believed that the short-term increase observed during 2013 was related to a 2010 rise in the water table which flushed residual Sr-90 from the unsaturated zone soils located beneath the building. The amount of Sr-90 in this deep soil zone is expected to diminish over time, and the engineered cap installed in 2011 is designed to prevent rainwater infiltration into the contaminated soils immediately below the BGRR.
- During 2014, tritium concentrations in the groundwater immediately downgradient of the HFBR continued to exceed the 20,000 pCi/L DWS in several wells, with a maximum concentration of 31,200 pCi/L.

- Tritium continued to be detected in the g-2 source area monitoring wells at concentrations above the 20,000 pCi/L DWS, with a maximum concentration of 37,100 pCi/L. Natural radioactive decay and dispersion has reduced tritium concentrations in the down-gradient portion of the g-2 tritium plume. In early 2014, remnants of the plume were detected near the National Synchrotron Light Source II facility, with tritium concentrations up to 31,400 pCi/L. Tritium concentrations were less than 20,000 pCi/L in temporary wells installed in January 2015.

7.5 Groundwater Treatment Systems

The primary mission of the CERCLA program is to operate and maintain groundwater treatment systems to remediate contaminant plumes both on- and off-site. Modifications to groundwater remediation systems are implemented, as necessary, based upon a continuous evaluation of monitoring data and system performance. The cleanup objectives will be met by a combination of active treatment and natural attenuation. The specific cleanup goals are as follows:

- Achieve maximum contaminant levels (MCLs) for VOCs in the Upper Glacial aquifer by 2030.
- Achieve MCLs for VOCs in the Magothy aquifer by 2065.
- Achieve MCLs for Sr-90 at the BGRR in the Upper Glacial aquifer by 2070.
- Achieve MCLs for Sr-90 at the Chemical Holes in the Upper Glacial aquifer by 2040.

During 2014, BNL continued to make significant progress in restoring groundwater quality. Figure 7-4 shows the locations of 12 groundwater treatment systems currently in operation. Table 7-1 provides a summary of the amount of VOCs and Sr-90 removed from the aquifer since the start of active remediation in December 1996. During 2014, approximately 143 pounds of VOCs and nearly 1.2 mCi of Sr-90 were removed from the groundwater, and nearly 1.3 billion gallons of treated groundwater were returned to the aquifer.

To date, 7,276 pounds of VOCs have been removed from the aquifer and noticeable

CHAPTER 7: GROUNDWATER PROTECTION

Table 7-1. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2014.

Remediation System	Start Date	1997-2013		2014	
		Water Treated (Gallons)	VOCs Removed (Pounds) (e)	Water Treated (Gallons)	VOCs Removed (Pounds) (e)
OU I South Boundary (a)	12/1996	4,177,473,000	369	0	0
OU III HFBR Tritium Plume (a)	05/1997	721,795,000	180	0	0
OU III South Boundary	06/1997	4,383,751,850	2,956	266,919,000	33
OU III Industrial Park	09/1999	1,976,798,330	1,061	68,114,000	2
OU III Carbon Tetrachloride (d)	10/1999	153,538,075	349	Decommissioned	0
OU III Building 96	01/2001	379,407,416	127	39,196,000	7
OU III Middle Road	10/2001	2,547,348,550	1,082	249,371,000	58
OU III Western South Boundary	09/2002	1,276,784,000	116	99,745,000	6
OU III Industrial Park East (e)	06/2004	357,192,000	38	Decommissioned	0
OU III North Street	06/2004	1,503,117,000	329	44,063,000	4
OU III North Street East	06/2004	955,558,000	43	53,000,000	1
OU III LIPA/Airport	08/2004	2,261,529,000	363	231,287,000	24
OU III Building 452 Freon-11	03/2012	58,312,000	88	37,484,000	8
OU IV AS/SVE (b)	11/1997	(c)	35	Decommissioned	0
OU VI EDB	10/2004	1,410,664,000	(g)	176,502,000	(g)
Total		22,163,268,221	7,133	1,265,681,000	143

Remediation System	Start Date	2003-2013		2014	
		Water Treated (Gallons)	Sr-90 Removed (mCi)	Water Treated (Gallons)	Sr-90 Removed (mCi)
OU III Chemical Holes Sr-90	02/2003	51,335,826	4.69	4,402,000	0.09
OU III BGRR/WCF Sr-90	06/2005	79,082,000	24.02	8,750,000	1.1
Total		130,417,826	28.71	13,152,000	1.19

Notes:

- (a) System placed in standby mode in 2013.
- (b) System decommissioned in 2003.
- (c) Air Sparging/Soil Vapor Extraction (AS/SVE) system performance was measured by pounds of VOCs removed per cubic feet of air treated.
- (d) System decommissioned in 2010.
- (e) System decommissioned in 2013.
- (f) Values are rounded to the nearest whole number.
- (g) Because EDB has only been detected at trace levels in the treatment system influent, no removal of VOCs is reported.

BGRR = Brookhaven Graphite Research Reactor
 EDB = ethylene dibromide
 HFBR = High Flux Beam Reactor
 LIPA = Long Island Power Authority
 OU = operable unit
 VOCs = volatile organic compounds
 WCF = Waste Concentration Facility

improvements in groundwater quality are evident in a number of on- and off-site areas. Furthermore, two of the treatment systems have removed approximately 30 mCi of Sr-90.

During 2014, BNL received regulatory agency approval to shut down the North Street

East Treatment System. The North Street East System, along with the OU I South Boundary Treatment System, OU III Industrial Park Treatment System, and the HFBR Tritium Pump and Recharge System which were shut down earlier, met their active remediation goals for reduction of

Figure 7-4. Locations of BNL Groundwater Remediation Systems.

CHAPTER 7: GROUNDWATER PROTECTION

contaminant concentrations. A period of standby monitoring for the plumes associated with these treatment systems will be performed to detect any rebound of contaminant concentrations. Detailed information on the groundwater contaminant plumes and treatment systems can be found in SER Volume II, Groundwater Status Report.

REFERENCES AND BIBLIOGRAPHY

BNL 2013. *Groundwater Protection Contingency Plan – Response to Unexpected Monitoring Results*. Environmental Monitoring Procedure EM-SOP-309. Brookhaven National Laboratory, Upton, NY. August 2013.

BNL 2014. *Petition for Shutdown OU III North Street East Groundwater Treatment System*. Brookhaven National Laboratory, Upton, NY. April 2, 2014.

Radiological Dose Assessment

BNL's annual radiological dose assessment assures stakeholders that on-site facilities and BNL operations are in compliance with federal, state, and local regulations, and that the public is protected. The potential radiological dose to members of the public is calculated at an off-site location (residence, school, or an office) closest to an emission source as the maximum dose that could be received by an off-site individual, defined as the "maximally exposed off-site individual" (MEOSI). Based on MEOSI dose calculation criteria, members of the public will receive a dose less than the MEOSI under all circumstances. The dose to the MEOSI is the sum total from direct and indirect dose pathways via air immersion, inhalation of particulates and gases, and ingestion of local fish and deer meat. In 2014, the total effective dose (TED) of 3.15 mrem (32 μ Sv) from Laboratory operations was well below the EPA and DOE regulatory dose limits for the public, workers, and the environment.

The effective dose equivalent (EDE) from air emissions in 2014 was estimated at 2.85E-01 mrem (2.9 μ Sv) to the MEOSI. The BNL dose from the inhalation pathway was less than three percent of the EPA's annual regulatory dose limit of 10 mrem (100 μ Sv). In addition, the dose from the ingestion pathway was estimated as 2.80 mrem (28 μ Sv) from the consumption of deer meat and 6.3E-2 mrem (0.63 μ Sv) from the consumption of fish caught in the vicinity of the Laboratory. In summary, the total annual dose to the MEOSI from all pathways was estimated at 3.15 mrem (32 μ Sv), which is less than 4 percent of DOE's 100-mrem limit. The aggregate population dose was 0.563 person-rem among approximately 6 million persons residing within a 50-mile radius of the Laboratory. On average, this is equivalent to a fraction of an airport whole body scan.

Dose to the maximally exposed individual (MEI) on-site and outside of controlled areas, calculated from TLD thermoluminescent dosimeter (TLD) monitoring records, was 8 mrem above natural background radiation levels in 2014. The average annual external dose from ambient sources on-site was 69 ± 9 mrem (690 ± 90 μ Sv) and 69 ± 8 mrem (690 ± 80 μ Sv) from off-site ambient sources. Both on- and off-site external dose measurements include the contribution from natural terrestrial and cosmic background radiation. A statistical comparison of the average doses measured using 58 on-site TLDs and 15 off-site TLDs showed that there was no external dose contribution from BNL operations distinguishable from the natural background radiation level.

Doses to aquatic and terrestrial biota were also evaluated and found to be well below DOE regulatory limits. Other short-term projects, such as remediation work and waste management disposal activities, were assessed for radiological emissions; the potential dose from each of these activities was below regulatory limits and there was minimal radiological risk to the public, workers, or the environment. In summary, the overall dose impact from all Laboratory activities in 2014 was comparable to natural background radiation levels.

8.0 INTRODUCTION

Chapter 8 discusses the dose risk consequences from research activities, radiation generating devices, facilities, and minor bench-top radiation sources at BNL. It is important to understand the health impacts of radiation to the public and workers, as well as radiation effects to the environment, fauna, and flora. The Laboratory's routine operations, scientific experiments, and new research projects are evaluated for their radiological dose risk. The dose risks from decommissioned facilities and decontamination work are also evaluated for dose impact. All environmental pathway scenarios that can cause a dose to humans, aquatic life, plants, and animals are evaluated to calculate the dose risks on site. Because all research reactors at BNL have been shut down, defueled, and partly or fully decommissioned, there was no dose risk from these facilities in 2014. The Laboratory's current radiological risks are from very small quantities of radionuclides used in the small sciences, radiopharmaceuticals produced at the Brookhaven Linac Isotope Producer (BLIP), and small amounts of air activation at the BNL accelerators: Alternating Gradient Synchrotron (AGS), Relativistic Heavy Ion Collider (RHIC), National Synchrotron Light Source (NSLS), and the future National Synchrotron Light Source II (NSLS-II), which began low-power testing in 2014. The radiological dose assessments are performed to ensure that dose risks from all Laboratory operations meet regulatory requirements and remain "As Low As Reasonably Achievable" (ALARA) to members of the public, workers, and the environment.

8.1 DIRECT RADIATION MONITORING

A direct radiation-monitoring program is used to measure the external dose contribution to the public and workers from radiation sources at BNL. This is achieved by measuring direct penetrating radiation exposures at both on- and off-site locations. The direct measurements taken at the off-site locations are with the premise that off-site exposures represent true natural background radiation (with contribution from both cosmic and terrestrial sources) and represent no contribution from Laboratory operations.

On- and off-site external dose measurements are averaged and then compared using the statistical t-test to assess the contribution, if any, from Laboratory operations.

8.1.1 Ambient Radiation Monitoring

To assess the dose impact of direct radiation from BNL operations, TLDs are deployed on site and in the surrounding communities. On-site TLD locations are determined based on the potential for exposure to gaseous plumes, atmospheric particulates, scattered radiation, and the location of radiation-generating devices. The Laboratory perimeter is also posted with TLDs to assess the dose impact, if any, beyond the site's boundaries. On- and off-site locations are divided into grids, and each TLD is assigned a unique identification code based on the grids.

In 2014, a total of 58 environmental TLDs were deployed on site, of which 9 were placed in known radiation areas and 15 were deployed at off-site locations (see Figures 8-1 and 8-2). Fourteen off-site TLDs are listed, but three were retired during the first quarter. Six off-site TLDs were added in the last quarter, of which four reported dose. An additional 30 TLDs were stored in a lead-shielded container for use as reference and control TLDs for comparison purposes. The average of the control TLD values, reported as "075-TLD4" in Tables 8-1 and 8-2, was 30 ± 3 mrem. This dose accounts for any small "residual" dose not removed during the annealing process and the natural background and cosmic radiation sources that are not completely shielded. The on- and off-site TLDs were collected and read quarterly to determine the external radiation dose measured.

Table 8-1 shows the quarterly and yearly on-site radiation dose measurements for 2014. The on-site average external doses for the first through fourth quarters were 17.1 ± 3.4 , 17.7 ± 3.8 , 16 ± 3.4 , and 18 ± 2.6 mrem, respectively. The on-site average annual external dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 69 ± 9 mrem (690 ± 90 μ Sv).

Table 8-2 shows the quarterly and yearly off-site radiation dose measurements for 2014. The off-site average external doses for the first

Figure 8-I. On-Site TLD Locations.

through fourth quarters were 16.6 ± 3.3 , 15.5 ± 11 , 15.1 ± 2.8 , and 16.6 ± 1.8 mrem, respectively. The off-site average annual ambient dose from all potential environmental sources, including cosmic and terrestrial radiation sources, was 69 ± 8 mrem (690 ± 80 μ Sv). Based upon a reevaluation of the TLD program, six new TLD locations were added, and three existing TLD locations were removed during the last quarter of 2014. The changes were made to cover all wind sector areas on the grid map for dose calculations.

To determine the BNL contribution to the external direct radiation dose, a statistical t-test between the measured on- and off-site external

dose averages was conducted. The t-test showed no significant difference between the off-site dose (69 ± 9 mrem) and on-site dose (69 ± 8 mrem) at the 95 percent confidence level. From the measured TLD doses, it can be safely concluded that there was no measurable external dose contribution to on- and off-site locations from Laboratory operations in 2014. The dose to the maximally exposed individual (MEI) on site and outside of controlled areas (in the vicinity of Building 356) was measured at 0 mrem (first quarter), 4 mrem (second quarter), 1 mrem (third quarter), and 3 mrem (fourth quarter) for 2014. The total dose to the on-site MEI was 8

Figure 8-2. Off-Site TLD Locations.

CHAPTER 8: RADIOLOGICAL DOSE ASSESSMENT

Table 8-1. On-Site Direct Ambient Radiation Measurements for 2014.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. ±2σ (95%)	Annual Dose ±2σ (95%)
		(mrem)					
011-TLD1	North Firebreak	14.0	14.2	12.6	17.8	15±4	58±15
013-TLD1	North Firebreak	16.7	16.732	15.8	16.5	16±1	66±3
025-TLD1	Bldg. 1010, Beam Stop 1	16.9	16.0	14.3	17.1	16±2	64±9
025-TLD4	Bldg. 1010, Beam Stop 4	14.7	16.7	15.6	16.9	16±2	64±7
027-TLD1	Bldg. 1002A South	14.1	15.5	13.4	15.3	15±2	58±7
027-TLD2	Bldg. 1002D East	15.5	15.7	12.7	17.7	15±4	62±14
030-TLD1	Northeast Firebreak	16.0	16.6	16.2	17.9	17±2	67±6
034-TLD1	Bldg. 1008, Collimator 2	16.7	17.6	15.3	17.2	17±2	67±7
034-TLD2	Bldg. 1008, Collimator 4	17.2	18.9	15.8	17.4	17±2	69±9
036-TLD1	Bldg. 1004B, East	15.2	16.1	13.5	15.6	15±2	60±8
036-TLD2	Bldg. 1004, East	19.8	23.7	15.3	18.7	19±6	77±24
037-TLD1	S-13	15.2	16.4	17.6	18.0	17±2	67±9
043-TLD1	North Access Road	21.4	18.2	16.9	20.0	19±3	77±14
043-TLD2	North of Meteorology Tower	17.0	18.1	17.5	17.4	18±1	70±3
044-TLD1	Bldg. 1006	17.4	17.7	14.9	17.2	17±2	67±9
044-TLD2	South of Bldg. 1000E	16.9	18.6	16.1	19.0	18±2	71±9
044-TLD3	South of Bldg. 1000P	15.6	16.5	14.3	15.9	16±2	62±6
044-TLD4	Northeast of Bldg. 1000P	17.6	18.1	16.4	18.0	18±1	70±5
044-TLD5	North of Bldg. 1000P	17.6	17.8	16.0	19.1	18±2	70±9
045-TLD1	Bldg. 1005S	15.7	15.4	14.6	18.2	16±3	64±11
045-TLD2	East of Bldg. 1005S	15.6	17.1	15.0	19.6	17±4	67±14
045-TLD3	Southeast of Bldg. 1005S	16.9	17.4	17.3	18.4	17±1	70±4
045-TLD4	Southwest of Bldg. 1005S	19.1	18.6	15.8	19.0	18±3	72±11
045-TLD5	West-Southwest of Bldg. 1005S	18.8	16.9	15.4	18.1	17±3	69±10
049-TLD1	East Firebreak	17.0	17.4	15.3	17.2	17±2	67±7
053-TLD1	West Firebreak	17.4	18.5	18.2	19.2	18±1	73±5
054-TLD1	Bldg. 914	21.9	21.8	15.8	18.1	19±5	78±21
063-TLD1	West Firebreak	19.3	19.2	18.5	19.4	19±1	76±3
066-TLD1	Waste Management Facility	15.3	14.7	14.0	17.3	15±2	61±10
073-TLD1	Meteorology Tower	17.5	17.8	16.7	18.6	18±1	71±5
074-TLD1	Bldg. 560	17.6	19.0	16.7	19.1	18±2	73±8
074-TLD2	Bldg. 907	19.1	16.5	16.1	17.2	17±2	69±9
080-TLD1	East Firebreak	18.5	19.9	17.2	20.5	19±3	76±11
082-TLD1	West Firebreak	20.2	18.8	19.8	20.1	20±1	79±4
084-TLD1	Tennis Courts	16.8	17.7	16.5	17.2	17±1	68±3
085-TLD1	TFCU	16.1	17.3	16.5	18.2	17±2	68±7
085-TLD2	Upton Gas Station	16.2	18.2	16.4	18.7	17±2	69±9
086-TLD1	Baseball Fields	17.6	18.3	18.2	16.8	18±1	71±5
090-TLD1	North St. Gate	16.2	16.2	15.3	18.7	17±3	66±10
105-TLD1	South Firebreak	16.5	18.3	17.1	18.9	18±2	71±8

(continued on next page)

Table 8-1. On-Site Direct Ambient Radiation Measurements for 2014 (concluded).

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. $\pm 2\sigma$ (95%)	Annual Dose $\pm 2\sigma$ (95%)
(mrem)							
108-TLD1	Water Tower	17.4	18.2	15.8	18.0	17 $\pm$ 2	69 $\pm$ 8
108-TLD2	Tritium Pole	19.2	24.2	19.7	21.4	21 $\pm$ 4	84 $\pm$ 16
111-TLD1	Trailer Park	18.2	18.7	18.5	18.3	18 $\pm$ 0	74 $\pm$ 1
122-TLD1	South Firebreak	15.7	17.3	18.7	18.6	18 $\pm$ 2	70 $\pm$ 10
126-TLD1	South Gate	18.1	18.7	18.8	20.0	19 $\pm$ 1	76 $\pm$ 5
P2		15.2	14.3	13.7	14.7	14 $\pm$ 1	58 $\pm$ 4
P4		16.2	18.8	15.8	16.1	17 $\pm$ 2	67 $\pm$ 10
P7		16.2	18.1	14.9	18.2	17 $\pm$ 3	67 $\pm$ 11
S5		16.0	16.1	14.0	17.8	16 $\pm$ 3	64 $\pm$ 11
On-site average		17.1	17.7	16.0	18.0	17 $\pm$ 2	69 $\pm$ 9
Std. Dev. (2s)		3.4	3.8	3.4	2.6		17 $\pm$ 3
075-TLD4: Control TLD Average		8.19	7.64	7.36	7.18	7.6 $\pm$ 1	30 $\pm$ 3

Notes :
See Figure 8-1 for TLD locations.
TLD = thermoluminescent dosimeter

mrem, which is less than the dose received from three round-trip flights from Los Angeles, California to New York, New York.

8.1.2 Facility Area Monitoring

Nine on-site TLDs were designated as facility-area monitors (FAMs) because they were posted in known radiation areas (near “facilities”). Table 8-3 shows the external doses measured with the FAM-TLDs. Environmental TLDs 088-TLD1 through 088-TLD4 are posted at the S-6 block-house location on the fence of the Former Hazardous Waste Management Facility (FHWMF). The TLDs measured external doses that were slightly elevated compared to the normal natural background radiation doses measured from other areas on site. This can be attributed to the presence of small amounts of contamination in soil. All TLD readings in this area were within 4 percent, except for 088-TLD1, which was approximately 14 percent higher, most likely due to Phase III soil remediation activities. However, a comparison of the current ambient dose rates to doses from previous years shows that the dose rates have significantly declined since the removal of contaminated soil within the FHWMF. The

FHWMF is fenced, access to it is controlled, and only trained radiological employees are allowed access to this area.

Two TLDs (075-TLD3 and 075-TLD5) near Building 356 showed slightly higher quarterly averages of 21.75 ± 2 mrem (218 ± 20 μ Sv) and 21 ± 7 mrem (210 ± 70 μ Sv), respectively, which are just above the normal ambient background radiation. The yearly doses were measured at 87 ± 8 mrem (870 ± 80 μ Sv) for 075-TLD3 and 84 ± 18 mrem (840 ± 180 μ Sv) for 075-TLD5. The direct doses are higher than the on-site annual average because Building 356 houses a cobalt-60 (Co-60) source, which is used to irradiate materials, parts, and electronic circuit boards. The slightly elevated dose from Building 356 on 075-TLD3 is attributed to the “sky-shine” phenomenon. This building also contains several Californium -252 (Cf-252) neutron sources in a cask near the corner of the building where 075-TLD5 is located. Although it is conceivable that individuals who use the parking lot adjacent to Building 356 could receive a dose from these sources, the dose would be small due to the low occupancy factor.

Two FAM-TLDs placed on fence sections

Table 8-2. Off-Site Direct Radiation Measurements for 2014.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Avg./Qtr. $\pm 2 \sigma$ (95%)	Annual Dose $\pm 2 \sigma$ (95%)
		(mrem)					
000-TLD4	Private property	14.0	22.5	14.2	16.0	17 $\pm$ 7	67 $\pm$ 28
000-TLD5	Longwood Estate	14.0	17.0	14.3	17.8	16 $\pm$ 3	63 $\pm$ 13
000-TLD7	Mid-Island Game Farm	16.8	15.4	16.0	16.5	16 $\pm$ 1	65 $\pm$ 5
000-TLD8	Private property	NP	NP	NP	NP	0 $\pm$ 0	0 $\pm$ 0
000-TLD9	Private property	NP	NP	NP	28.7	29 $\pm$ 0	115 $\pm$ 0
004-TLD1	Private property	NP	NP	NP	17.5	18 $\pm$ 0	70 $\pm$ 0
300-TLD3	Private property	NP	NP	NP	NP	0 $\pm$ 0	0 $\pm$ 0
400-TLD1	Calverton National Cemetery	18.4	21.2	18.4	18.2	19 $\pm$ 2	76 $\pm$ 10
500-TLD2	Private property	NP	0.0	NP	NP	0 $\pm$ 0	0 $\pm$ 0
500-TLD4	Private property	NP	NP	16.2	18.6	17 $\pm$ 2	70 $\pm$ 9
600-TLD3	Sportsmen's Club	17.2	16.5	15.9	16.1	16 $\pm$ 1	66 $\pm$ 4
700-TLD2	Private property	NP	NP	NP	NP	0 $\pm$ 0	0 $\pm$ 0
700-TLD3	Private property	16.0	14.4	13.6	15.2	15 $\pm$ 2	59 $\pm$ 7
700-TLD4	Private property	19.3	15.4	16.4	17.1	17 $\pm$ 3	68 $\pm$ 11
800-TLD1	Private property	15.9	15.6	15.5	16.9	16 $\pm$ 1	64 $\pm$ 4
800-TLD3	Suffolk County CD	16.2	17.0	14.5	17.1	16 $\pm$ 2	65 $\pm$ 8
900-TLD2	Private property	18.2	15.0	13.7	15.5	16 $\pm$ 3	62 $\pm$ 13
900-TLD4	Private property	NP	NP	NP	14.8	15 $\pm$ 0	59 $\pm$ 0
900-TLD5	Private property	NP	NP	NP	NP	0 $\pm$ 0	0 $\pm$ 0
999-TLD1	Private property	NP	NP	NP	17.2	17 $\pm$ 0	69 $\pm$ 0
Off-site average		16.6	15.5	15.1	16.6	17 $\pm$ 2	69 $\pm$ 8
Std. Dev. (2 σ)		3.3	11.0	2.8	1.8		
075-TLD4: Control TLD Average		8.2	7.6	7.4	7.2	7.6 $\pm$ 1	30 $\pm$ 3

Notes:
See Figure 8-2 for TLD locations.
CD = Correctional Department

NP = TLD not posted
TLD = thermoluminescent dosimeter

Table 8-3. Facility Area Monitoring, 2014.

TLD#	Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Average $\pm 2 \sigma$ (95%)	Annual Dose $\pm 2 \sigma$ (95%)
		(mrem)					
054-TLD2	Northeast of Bldg. 913B	24.9	25.3	15.8	20.9	22 $\pm$ 8	87 $\pm$ 31
054-TLD3	Northwest of Bldg. 913B	19.6	20.2	15.3	17.0	18 $\pm$ 4	72 $\pm$ 16
S6	FHWMF	18.1	17.7	18.1	19.2	18 $\pm$ 1	73 $\pm$ 4
088-TLD1	FHWMF, 50' East of S6	20.0	21.4	21.9	21.1	21 $\pm$ 1	84 $\pm$ 6
088-TLD2	FHWMF, 50' West of S6	19.4	19.2	19.1	20.0	19 $\pm$ 1	78 $\pm$ 3
088-TLD3	FHWMF, 100' West of S6	19.4	21.0	19.5	21.4	20 $\pm$ 2	81 $\pm$ 7
088-TLD4	FHWMF, 150' West of S6	16.9	18.7	16.8	18.7	18 $\pm$ 2	71 $\pm$ 7
075-TLD3	Bldg. 356	20.3	22.1	21.4	23.2	22 $\pm$ 2	87 $\pm$ 8
075-TLD5	North Corner of Bldg. 356	19.0	18.8	22.8	23.7	21 $\pm$ 4	84 $\pm$ 18

Notes:
See Figure 8-1 for TLD locations.
FHWMF = Former Hazardous Waste Management Facility

TLD = thermoluminescent dosimeter

northeast and northwest of Building 913B (the AGS tunnel access) showed slightly elevated above-average ambient external dose. The first-quarter dose at these sites was measured at 24.9 mrem for 054-TLD2 and 19.6 mrem for 054-TLD3 (compared to the site-wide first-quarter dose of 17.1 ± 3.4 and off-site dose of 16.6 ± 3.3 mrem). The second-quarter dose at these sites was measured at 25.3 mrem for 054-TLD2 and 20.2 mrem for 054-TLD3 (compared to the site-wide second-quarter dose of 17.7 ± 3.8 mrem and off-site dose of 15.5 ± 11 mrem). During the third quarter, both TLDs showed dose comparable to natural background radiation. In the fourth quarter, the 054-TLD2 site showed elevated dose of 20.9 mrem, while the other was at or below background. While the slightly higher levels of the first and second quarters are expected because the operating period for the AGS is typically in the first half of the calendar year, these dose levels are comparable to recent

years overall.

The AGS accelerates protons to energies up to 30 GeV and heavy ions up to 15 GeV/amu. RHIC has two beams circulating in opposite directions and is capable of accepting either protons or heavy ions up to gold. At the RHIC, protons and heavy ions received from the AGS are further accelerated up to final energies of 250 GeV for protons and 100 GeV per nucleon for gold ions. Under these high-energy conditions, facilities such as AGS and RHIC have the potential to generate high-energy neutrons when the charged particles leave the confines of the accelerator and produce nuclear fragments along their path or when they collide with matter. A passive monitoring TLD provides dose information from the neutron interactions when placed at strategic locations. In 2014, 12 neutron-monitoring TLDs (Harshaw Badge 8814) were posted at these strategic locations to measure the dose contribution from the high-energy neutrons (see Figure

Figure 8-3. On-Site Neutron TLD Locations.

8-3 for locations). The technical criteria used for the placement of the neutron TLDs is based on design aspects such as the thickness of the berm shielding, location of soil activation areas, beam stop areas and beam collimators, and proximity to the site boundary. In the first quarter of 2014, passive monitors for neutron dose showed no dose. In the second quarter, neutron TLDs at 025-TLD-N2, 043-TLD-N2, and 054-TLD-N2 showed neutron doses of 1 mrem, 1 mrem, and 2 mrem, respectively. Finally, four neutron TLDs 025-TLD-N2, 042-TLD-N1, 043-TLD-N1, and 043-TLD-N2, all showed neutron doses of 1 mrem in the third quarter. No neutron dose was found on neutron TLDs in the fourth quarter. The RHIC/BLIP runs at slightly higher current and energy during the beginning of the third quarter for approximately one month, but is turned off for the remainder of the third quarter. In the fourth quarter, the RHIC/BLIP runs for a two-week period at the end of the calendar year. These low-level neutron doses indicate that engineering controls (i.e. berm shielding) in place at AGS and RHIC are effective.

8.2 DOSE MODELING

EPA regulates radiological emissions from DOE facilities under the requirements set forth in 40 CFR 61, Subpart H, entitled, “National Emission Standards for Hazardous Air Pollutants (NESHAPs).” This regulation specifies the compliance and monitoring requirements for reporting radiation doses received by members of the public from airborne radionuclides. The regulation mandates that no member of the public shall receive a dose that is greater than 10 mrem (100 μ Sv) in a year from airborne emissions. The emission monitoring requirements are set forth in Subpart H, Section 61.93(b) and include the use of a reference method for continuous monitoring at major release points (defined as those with a potential to exceed 1 percent of the 10 mrem standard) and a periodic confirmatory measurement for all other release points. The regulations also require DOE facilities to submit an annual NESHAPs report to EPA that describes the major and minor emission sources and dose to the MEOSI. The dose estimates from various facilities are given in Table 8-4,

and the actual air emissions for 2014 are discussed in detail in Chapter 4.

As a part of the NESHAPs review process at BNL, any source that has the potential to emit radioactive materials is evaluated for regulatory compliance. Although the activities conducted by the Laboratory’s Environmental Restoration Programs are exempt under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), these activities are also monitored and assessed for any potential to release radioactive materials and to determine their dose contribution, if any, to the environment. Currently, any new radiological processes or activities are also evaluated for compliance with NESHAPs regulations using EPA’s approved dose modeling software (see Section 8.2.1 for details). Because this model is designed to treat radioactive emission sources as continuous over the course of a year, it is not well-suited for estimating short-term or acute releases. Consequently, it overestimates potential dose contributions from short-term projects and area sources. For that reason, dose model results are considered to be “conservative”—that is, erring on the side of caution.

8.2.1 Dose Modeling Program

Compliance with NESHAPs regulations is demonstrated through the use of EPA dose modeling software and the Clean Air Act Assessment Package 1988 (CAP88-PC). This computer program uses a Gaussian plume model to estimate the average dispersion of radionuclides released from elevated stacks or diffuse sources. It calculates a final value of the projected dose at the specified distance from the release point by computing dispersed radionuclide concentrations in air, rate of deposition on ground surfaces, and intake via the food pathway (where applicable). CAP88-PC calculates both the EDE to the MEOSI and the collective population dose within a 50-mile radius of the emission source. In most cases, the CAP88-PC model provides conservative doses. For the purpose of modeling the dose to the MEOSI, all emission points are co-located at the BLIP Facility located in the developed portion of the site. The dose calculations are based on very low concentrations of

environmental releases and on chronic, continuous intakes in a year. The input parameters used

in the model include radionuclide type, emission rate in curies (Ci) per year, stack parameters

Table 8-4. Maximally Exposed Off-site Individual Effective Dose Equivalent From Facilities or Routine Processes, 2014.

Building No.	Facility or Process	Construction Permit No.	MEOSI Dose (mrem) (a)	Notes
197	Nonproliferation & Nuclear Safety	None	1.57E-12	(b)
197B	Nonproliferation & Nuclear Safety	None	2.65E-08	(b)
348	Instrumentation & Calibration	None	ND	(d)
463	Biology	None	1.03E-08	(b)
480	Condensed Matter Physics	None	ND	(d)
490	Radiation Therapy Facility	BNL-489-01	ND	(e)
490/490A	Medical Research	None	5.60E-06	(b)
491	Brookhaven Medical Research Reactor	None	ND	(e)
510	Calorimeter Enclosure	BNL-689-01	ND	(f)
510A	Physics	None	5.49E-14	(b)
535	Instrumentation	None	4.10E-14	(b)
555	Chemistry Facility	None	ND	(l), (k)
725	National Synchrotron Light Source	None	2.30E-08	(b)
734	Interdisciplinary Science Building	None	1.75E-16	(b)
750	High Flux Beam Reactor	None	6.73E-05	(c)
801	Target Processing lab	None	5.19E-04	(b), (c)
802B	Evaporator Facility	BNL-288-01	ND	(e)
815	Environmental Chemistry	None	2.64E-07	(b)
820	Accelerator Test Facility	BNL-589-01	ND	(d)
830	Environmental Science Department	None	ND	(d)
865	Waste Management Facility	None	ND	(j)
901	BioSciences Department	None	1.49E-08	(b)
902	Superconducting Magnet Division	None	1.41E-11	(b)
906	Medical-Chemistry	None	ND	(i)
911	Alternating Gradient Synchrotron	None	ND	(d)
925	Accelerator Department	None	ND	(i)
931	Brookhaven Linac Isotope Producer	BNL-2009-01	2.84E-01	(c)
938	REF/NBTF	BNL-789-01	ND	(f), (g)
942	Alternating Gradient Synchrotron Booster	BNL-188-01	ND	(h)
---	Relativistic Heavy Ion Collider	BNL-389-01	ND	(d)
Total Potential Dose from BNL Operations			2.85E-01	
EPA Limit (Air Emissions)			10	

Notes:

MEOSI = Maximally Exposed Off-site Individual

ND = No dose

(a) "Dose" in this table means effective dose equivalent to MEOSI.

(b) Dose is based on emissions calculated using 40CFR61, Appendix D methodology.

(c) Emissions are periodically monitored at the facility.

(d) No Dose from emissions source in 2014.

(e) NO = Not Operational in 2014.

(f) This facility was decommissioned and has been a zero-emission facility.

(g) This facility is no longer in use; it produces no radioactive emissions.

(h) Booster ventilation system prevents air release through continuous air recirculation.

(i) No radiological dispersible material inventory in 2014.

(j) No detectable emissions from the Waste Management Facility in 2014.

(k) Sealed sources were excluded from this inventory--no emission.

such as height and diameter, and emission exhaust velocity. Site-specific weather and population data are factored into the dose assessment. Weather data are supplied by measurements from the Laboratory's meteorological towers. These measurements include wind speed, direction, and frequency, as well as air temperature and precipitation amounts (see Chapter 1 for details). A population of 6 million (6,031,539) people, based on the Geographical Information System design population survey performed by Oak Ridge National Laboratory for BNL, was used in the model (ORNL 2012).

For the last several years, Version 3 of the dose modeling software CAP88-PC has been used to estimate dose due to the air immersion pathway from BNL operations. The 2014 effective dose equivalents were estimated using Version 4, which was released via a notice in the Federal Register on February 10, 2015. It has been noted that calculated dose values have generally decreased from those calculated using the last version of CAP88-PC, Version 3. The Federal Register notice attributes this primarily to intake factors in Version 4 that were updated "to be consistent with the latest version of the EPA Exposure Factors Handbook".

8.2.2 Dose Calculation Methods and Pathways

8.2.2.1 Maximally Exposed Off-site and On-site Individual

The MEOSI is defined as a person who resides at a residence, office, or school beyond the BNL site boundary such that no other member of the public could receive a higher dose than the MEOSI. This person is assumed to reside 24 hours a day, 365 days a year, off site, and close to the nearest emission point of the BNL site boundary. This person is also assumed to consume significant amounts of fish and deer containing radioactivity assumed to be attributable to Laboratory operations based on projections from the New York State Department of Health (NYSDOH). In reality, it is highly unlikely that such a combination of "maximized dose" to any single individual would occur, but the concept is useful for evaluating maximum potential risk and dose to members of the public. The on-site maximally exposed individual

who could receive any dose outside of BNL's controlled areas was determined by and monitored with TLD measurements.

8.2.2.2 Effective Dose Equivalent

The EDE to the MEOSI from low levels of radioactive materials dispersed into the environment was calculated using the CAP88-PC dose modeling program, Version 4. Site meteorology data were used to calculate annual dispersions for the midpoint of a given wind sector and distance. Facility-specific radionuclide emission rates (Ci/yr) were used for continuously monitored facilities. For small sources, the emissions were calculated using the method set forth in 40 CFR 61, Appendix D. The Gaussian dispersion model calculated the EDE at the site boundary and the collective population dose values from the immersion, inhalation, and ingestion pathways. As stated above, these dose and risk calculations to the MEOSI are based on low emissions and chronic intakes.

8.2.2.3 Dose Calculation: Fish Ingestion

To calculate the EDE from the fish consumption pathway, the intake is estimated. The term "Intake" is defined as the average amount of fish consumed by a person engaged in recreational fishing on the Peconic River. Based on a NYSDOH study, the consumption rate is estimated at 15 pounds (7 kg) per year (NYSDOH 1996). For each radionuclide of concern for fish samples, the dry weight activity concentration was converted to picocuries per gram (pCi/g) "wet weight," since wet weight is the form in which fish are caught and consumed. A dose conversion factor was used for each radionuclide to convert the activity concentration into the EDE. For example, the committed dose equivalent conversion factor for Cesium-137 (Cs-137) is $5.0\text{E-}02 \text{ rem}/\mu\text{Ci}$, as set forth in DOE/EH-0071 (DOE 1988). The dose was calculated as: $\text{dose (rem/yr)} = \text{intake (kg/yr)} \times \text{activity in flesh } (\mu\text{Ci/kg}) \times \text{dose conversion factor (rem}/\mu\text{Ci})$.

8.2.2.4 Dose Calculation: Deer Meat Ingestion

The dose calculation for the deer meat ingestion pathway is similar to that for fish consumption. The Cs-137 radionuclide dose conversion

factor was used to estimate dose, based on the U.S. Environmental Protection Agency Exposure Factors Handbook (EPA 1996). No other radionuclides associated with Laboratory operations have been detected in deer meat. The total quantity of deer meat ingested during the course of a year was estimated at 64 pounds (29 kg) (NYSDOH 1999).

8.3 SOURCES: DIFFUSE, FUGITIVE, "OTHER"

Diffuse sources, also known as nonpoint or area sources, are described as sources of radioactive contaminants which diffuse into the atmosphere but do not have well-defined emission points. Fugitive sources include leaks through window and door frames, as well as unintended releases to the air through vents or stacks which are supposedly inactive (i.e., leaks from vents are fugitive sources). As part of the NESHAPs review process, in addition to stack emissions, any fugitive or diffuse emission source that could potentially emit radioactive materials to the environment is evaluated. Although CERCLA-prompted actions, such as remediation projects, are exempt from procedural requirements to obtain federal, state, or local permits, any BNL activity or process with the potential to emit radioactive material must be evaluated and assessed for dose impact to members of the public. The following radiological sources were evaluated in 2014 for potential contribution to the overall site dose: Building 801, Building 750 complex (HFBR), and Building 906 (Scanner Rooms 5 & 6).

8.3.1 Remediation Work

At the site of the FHWMF, Phase Three of the perimeter soil remediation component of the project was performed. During previous phases of the project, the area designated for soil remediation was sub-divided into a grid of 16 zones. Each zone was plotted on a grid map, then surveyed to locate discrete spots of elevated Cs-137 activity in the soil. The goal of Phase Three was to use the grid map, with its discrete spots, to mark, remove, survey, isolate, and dispose of contaminated soil in Supersaks on a nearby rail car. All soil that contained contamination above 21,000 cpm (the equivalent of 23 pCi/g Cs-137)

was removed. When the amount and activity of soil had been removed such that soil activity did not exceed 15,000 cpm, the remediation work was considered complete. Some 64-cubic yards of contaminated soil were removed and sent off site for disposal.

8.4 DOSE FROM POINT SOURCES

8.4.1 Brookhaven LINAC Isotope Producer

Source term descriptions for point sources are given in Chapter 4. The BLIP facility is the only emission source with the potential to contribute dose to members of the public greater than 1 percent of the EPA limit (0.1 mrem or 1.0 μ Sv). The BLIP facility is considered a major emission source in accordance with the ANSI N13.1-1999 standard's graded approach; that is, a Potential Impact Category (PIC) of II. The emissions are directly and continuously measured in real time with an in-line, low-resolution sodium iodide (NaI) gamma spectrometer connected to the exhaust ventilation system for recording emissions. The particulate emissions are sampled weekly using a conventional fiberglass filter, which is analyzed at an off-site contract analytical laboratory. Likewise, tritium samples are also collected continuously using a silica gel absorbent and are then analyzed at an off-site contract analytical laboratory on a biweekly basis.

In 2014, the BLIP facility operated over a period of 32 weeks. During the year, 2,511 Ci of C-11 (half-life: 20 minutes) and 5,023 Ci of O-15 (half-life: 122 seconds) were released from the BLIP facility. A small quantity (3.25E-02 Ci) of tritiated water vapor from activation of the targets' cooling water was also released. The EDE to the MEOSI was calculated to be 2.84-01 mrem (2.8 μ Sv) in a year from BLIP operations.

8.4.2 High Flux Beam Reactor

In 2014, the residual tritium emissions from the HFBR Facility were measured at 0.487 Ci, and the estimated dose attributed was 6.73E-5 mrem (0.67 nSv) in a year.

8.4.3 Brookhaven Medical Research Reactor

In 2014, the Brookhaven Medical Research Reactor (BMRR) facility remained in a cold-shutdown mode as a radiological facility with

institutional controls in place. There was no dose contribution from the BMRR in 2014.

8.4.4 Brookhaven Graphite Research Reactor

In 2014, long-term surveillance of the BGRR continued, as well as the maintenance and periodic refurbishment of structures, systems, and components. This will continue throughout the period of radioactive decay. There was no dose contribution from the BGRR during 2014.

8.4.5 Waste Management Facility

In 2014, there were no detectable levels of emissions from the Waste Management Facility.

8.4.6 Unplanned Releases

There were no reported unplanned releases in 2014.

8.5 DOSE FROM INGESTION

Radionuclides in the environment bio-accumulate in deer and fish tissues, bones, and organs; consequently, samples from deer and fish are analyzed to evaluate the dose contribution to humans from the ingestion pathway. As discussed in Chapter 6, deer meat samples collected off-site and less than 1 mile from the BNL boundary were used to assess the potential dose impact to the MEOSI for 2014. The maximum tissue concentration in the deer meat (flesh) collected “off site” was used to calculate the potential dose to the MEOSI. Potassium-40 (K-40) and Cs-137 were detected in the tissue samples. K-40 is a naturally-occurring radionuclide and is not related to BNL operations.

In 2014, the maximum Cs-137 concentrations were 1.93 ± 0.04 pCi/g (wet weight) in the flesh (off site < 1 mile) and 1.07 ± 0.03 pCi/g (wet weight) in the liver (off site < 1 mile) (see Table 6-2). The average Cs-137 concentration from all samples was calculated at 0.46 ± 0.13 pCi/g; however, the maximum concentration of 1.93 pCi/g was used for the purpose of MEOSI dose calculations. The maximum estimated dose to humans from consuming deer meat containing the maximum Cs-137 concentration was estimated to be 2.8 mrem (28 μ Sv) in a year. This dose is below the health advisory limit of 10 mrem (100 μ Sv) established by NYSDOH.

In collaboration with the New York State Department of Environmental Conservation (NYSDEC) Fisheries Division, the Laboratory maintains an ongoing program of collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. In 2014, a large-mouth bass species had the highest measured concentration of Cs-137 at 0.18 ± 0.03 pCi/g; this was used to estimate the EDE to the MEOSI. The potential dose from consuming 15 pounds of such fish annually was calculated to be 6.3E-2 mrem (0.63 μ Sv)—well below the NYSDOH health advisory limit of 10 mrem.

8.6 DOSE TO AQUATIC AND TERRESTRIAL BIOTA

DOE-STD-1153-2002, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota, provides the guidelines for screening methods to estimate radiological doses to aquatic animals and terrestrial plants and animals, using site-specific environmental surveillance data. The RESRAD-BIOTA 1.5, biota dose level 2 computer program was used to evaluate compliance with the requirements for protection of biota specified in DOE Order 458.1, Radiation Protection of the Public and the Environment.

In 2014, the terrestrial animal and plant doses were evaluated based on 0.44 pCi/g of Cs-137 (see Table 6-9) found in surface soils around the West end of Brookhaven Avenue and a strontium-90 (Sr-90) concentration of 0.61 pCi/L (see Table 5-5) in the surface waters collected at the HM-N location. The dose to terrestrial animals was calculated to be 21.2 μ Gy/day, and to plants, 1.99 μ Gy/day. The dose to terrestrial animals were well below the biota dose limit of 1 mGy/day, and below the limit for terrestrial plants.

To calculate the dose to aquatic and riparian animals, Sr-90 radionuclide concentration values for surface water from the HM-N location (see Table 5-5) and the Cs-137 in sediments found at PR-WC-06-D1-L50 were used (see Table 6-7). The Cs-137 sediment concentration at PR-WC-06-D1-L50 was 5.49 pCi/g and the Sr-90 concentration in surface water at HM-N was 0.61 pCi/L. The calculated dose to aquatic animals was 106 μ Gy/day and the dose to

Table 8-5. BNL Site Dose Summary, 2014.

Pathway	Dose to Maximally Exposed Individual	Percent of DOE 100 mrem/year Limit	Estimated Population Dose per year
Inhalation			
Air	2.85E-01	<1%	0.563 Person-rem
Ingestion			
Drinking Water	None	None	None
Fish	6.30E-02	<1%	Not Tracked
Deer	2.8	<3%	Not Tracked
All Pathways	3.15 mrem	<4%	0.563 Person-rem

riparian animals was 261 $\mu\text{Gy/day}$. Therefore, the dose to aquatic and riparian animals was also well below the 10 mGy/day limit specified by the regulations.

8.7 CUMULATIVE DOSE

Table 8-5 summarizes the potential cumulative dose from the BNL site in 2014. The total dose to the MEOSI from air and ingestion pathways was estimated to be 3.15 mrem (32 μSv). In comparison, the EPA regulatory limit for the air pathway is 10 mrem (0.10 mSv) and the DOE limit from all pathways is 100 mrem (1 mSv). The cumulative population dose was 0.563 person-rem (5.6E-3 person-Sv) in a year. The effective dose is well below the DOE and EPA regulatory limits, and the ambient TLD dose is within normal background levels seen at the Laboratory site. The potential dose from drinking water was not estimated, because most residents adjacent to the BNL site get their drinking water from the Suffolk County Water Authority rather than private wells. To put the potential dose impact into perspective, a comparison was made with estimated doses from other sources of radiation. The annual dose from all natural background sources and radon is approximately 311 mrem (3.11 mSv). A mammogram gives a dose of 250 mrem (2.5 mSv) and a dental x-ray gives a dose of approximately 160 mrem (1.6 mSv) to an individual. Therefore, a dose of 3.15 mrem from all environmental pathways is a minute fraction of the dose from one routine dental x-ray.

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Quality Assurance

9

Quality assurance is an integral part of every activity at Brookhaven National Laboratory. A comprehensive Quality Assurance/Quality Control (QA/QC) Program is in place to ensure that all environmental monitoring samples are representative and that data are reliable and defensible. The QC in the contract analytical laboratories is maintained through daily instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated, as required, by project-specific quality objectives before being used to support decision making. The multilayered components of QA monitored at BNL ensure that all analytical data reported in the 2014 Site Environmental Report are reliable and of high quality.

9.1 QUALITY PROGRAM ELEMENTS

As required by DOE Order 458.1, *Radiation Protection of the Public and Environment*, and DOE Order 436.1, *Departmental Sustainability*, BNL has established a QA/QC Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent with the requirements of Title 10 of the Code of Federal Regulations, Part 830 10 CFR 830, Subpart A, *Quality Assurance Requirements* (2000), and DOE Order 414.1D, *Quality Assurance*. The responsibility for quality at BNL starts with the Laboratory director, who approves the policies and standards of performance governing work, and extends throughout the entire organization. The purpose of the BNL Quality Management (QM) System is to implement QM methodology throughout the various Laboratory management systems and associated processes, in order to:

- Plan and perform operations in a reliable and effective manner to minimize any impact on the environment, safety, security, and health of the staff and public.
- Standardize processes and support continual improvement.
- Enable the delivery of products and services that meet customers' requirements and expectations.
- Support an environment that facilitates scientific and operational excellence.

For environmental monitoring, QA is deployed as an integrated system of management activities. These activities involve planning, implementation, control, reporting, assessment, and continual improvement. QC activities measure each process or service against the QA standards. QA/QC practices and procedures are documented in manuals, plans, and a comprehensive set of standard operating procedures (SOPs) for environmental monitoring (EM-SOPs). Staff members who must follow these procedures are required to document that they have reviewed and understand them.

The ultimate goal of the environmental monitoring and analysis QA/QC program is to ensure that results are representative and defensible, and that data are of the type and quality needed to verify protection of the public, employees, and the environment. Figure 9-1 depicts the flow of the QA/QC elements of BNL's Environmental Monitoring Program and indicates the sections of this chapter that discuss each element in more detail.

Laboratory environmental personnel determine sampling requirements using the EPA Data Quality Objective (DQO) process (EPA 2006) or its equivalent. During this process, the project manager for each environmental program determines the type, amount, and quality of data needed to support decision making, the legal requirements, and stakeholder concerns.

Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.

An environmental monitoring plan or project-specific sampling plan is then prepared, specifying the location, frequency, type of sample, analytical methods to be used, and a sampling schedule. These plans and the EM-SOPs also specify data acceptance criteria.

Contracts with off-site contract analytical laboratories are established for sampling analysis. The EM-SOPs direct sampling technicians on proper sample collection, preservation, and handling requirements. Field QC samples are prepared as necessary and analyzed in the field or at a certified contract analytical laboratory. The results are then validated or verified in accordance with published procedures. Finally, data are reviewed and evaluated by environmental professionals and management in the context of expected results, related monitoring results, historical data, and applicable regulatory requirements (e.g., drinking water standards, permit limits, etc.). The data are used to support decision making, reported as required, and summarized in this annual report.

9.2 SAMPLE COLLECTION AND HANDLING

In 2014, environmental monitoring samples were collected, as specified, by EM-SOPs, the BNL Environmental Monitoring Plan Update (BNL 2014a), and project-specific work plans. BNL has sampling SOPs for all environmental media, including groundwater, surface water, soil, sediment, air, flora, and fauna. These procedures contain detailed information on how to prepare for sample collection; what type of field equipment to use and how to calibrate it; how to properly collect, handle, and preserve samples; and how to manage any wastes generated during sampling. These procedures also ensure consistency between samples collected by Laboratory sampling personnel and contractors used to support the environmental restoration, compliance, and surveillance programs.

QC checks of sampling processes include the collection of field duplicates, matrix spike samples, field blanks, trip blanks, and equipment blanks.

9.2.1 FIELD SAMPLE HANDLING

To ensure the integrity of samples, chain-of-custody (COC) was maintained and documented for all samples collected in 2014. A sample is considered to be in the custody of a person if any or all of the following rules of custody are met: 1) the person has physical possession of the sample, 2) the sample remains in view of the person after being in possession, 3) the sample is placed in a secure location by the custody holder, or 4) the sample is in a designated secure area. These procedures are outlined in EM-SOP 109, “Chain-of-Custody, Storage, Packaging, and Shipment of Samples” (BNL 2010a). All environmental monitoring samples collected in 2014 maintained a valid COC from the time of sample collection through sample disposal by the contract analytical laboratories used by BNL.

9.2.1.1 Custody and Documentation

Field sampling technicians are responsible for the care and custody of samples until they are transferred to a receiving group or contract analytical laboratory. Samples requiring refrigeration are placed immediately into a refrigerator or a cooler with cooling media, and are kept under custody rules. The technician signs the COC form when relinquishing custody and contract analytical laboratory personnel sign the COC form when accepting custody.

As required by EM-SOP-201, “Documentation of Field Activities” (BNL 2012a), field sampling technicians are also required to maintain bound, weatherproof field logbooks, which are used to record sample ID numbers, collection times, descriptions, collection methods, and COC numbers. Daily weather conditions, field measurements, and other appropriate site-specific observations also are recorded in the logbooks.

9.2.1.2 Preservation and Shipment

Before sample collection, field sampling technicians prepare all bottle labels and affix them to the appropriate containers, as defined in the QA program plan or applicable EM-SOPs. Appropriate preservatives are added to the containers before or immediately after collection, and samples are refrigerated as necessary. For example, samples collected for methyl mercury are cooled

immediately and shipped to a contract analytical laboratory on the day of collection. After samples arrive at the contract analytical laboratory, they are preserved with hydrochloric acid.

Sample preservation is maintained, as required, throughout shipping. If samples are sent via commercial carrier, a bill-of-lading is used. COC seals are placed on the shipping containers; their intact status upon receipt indicates that custody was maintained during shipment. These procedures are outlined in EM-SOP 109, “Chain-of-Custody, Storage, Packaging, and Shipment of Samples.”

9.2.2 FIELD QUALITY CONTROL SAMPLES

Field QC samples collected for the environmental monitoring program include equipment blanks, trip blanks, field blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. The rationale for selecting specific field QC samples, and minimum requirements for their use in the Environmental Monitoring Program, are provided in the BNL EM-SOP 200 series, “Quality Assurance.” Equipment blanks and trip blanks were collected for all appropriate media in 2014.

An *equipment blank* is a volume of solution (in this case, laboratory-grade water) that is used to rinse a sampling tool after decontamination. The rinse water is collected and tested to verify that the sampling tool is not contaminated. Equipment blank samples are collected, as needed, to verify the effectiveness of the decontamination procedures on non-dedicated or reusable sampling equipment.

A *trip blank* is provided with each shipping container of samples to be analyzed for volatile organic compounds (VOCs). The use of trip blanks provides a way to determine whether contamination of a sample container occurred during shipment from the manufacturer, while the container was in storage, during shipment to a contract analytical laboratory, or during analysis of a sample at a contract analytical laboratory. Trip blanks consist of an aliquot of laboratory-grade water sealed in a sample bottle, usually prepared by the contract analytical laboratory prior to shipping the sample bottles to BNL. If trip blanks are not provided by the

contract analytical laboratory, then field sampling technicians prepare trip blanks before they collect the samples. Trip blanks were included with all shipments of aqueous samples for VOC analysis in 2014.

Field blanks are collected to check for cross-contamination that may occur during sample collection. A field blank consists of an aliquot of laboratory-grade water that is poured into a sample container in the field. For the Groundwater Monitoring Program, one field blank is collected for every 20 samples, or one per sampling round, whichever is more frequent. Field blanks are analyzed for the same parameters as groundwater samples. For other programs, the frequency of field blank collection is based on their specific DQOs.

In 2014 (as in other years), the most common contaminants detected in the trip, field, and equipment blanks included trace to low levels of chloroform, methyl chloride, and methylene chloride. These compounds are commonly detected in blanks and do not pose significant problems with the reliability of the analytical results. Several other compounds were also detected, such as methyl bromide and toluene, at low levels. When these contaminants are detected, validation or verification procedures are used, where applicable, to qualify the associated data as “nondetects” (see Section 9.4). The results from blank samples collected during 2014 did not indicate any significant impact on the quality of the results.

Field duplicate samples are analyzed to check the reproducibility of sampling and analytical results, based on EPA Region II guidelines (EPA 2012, 2013). For example, in the Groundwater Monitoring Program, duplicates are collected for 5 percent of the total number of samples collected for a project per sampling round.

During 2014, a total of 228 duplicate samples were collected for non-radiological analyses and 253 duplicates were collected for radiologic analyses. Not all parameters were analyzed in every duplicate. The parameters in each duplicate were consistent with those required for the specific program the duplicate was monitoring. Of the 13,060 parameters analyzed, only 124 (0.94 percent) of the non-radiologic analyses

failed to meet QA criteria. For the radiologic parameters, only 77 of the 885 parameters (8.7 percent) failed to meet QA criteria. The results are indicative of consistency with the contract analytical laboratories and sampling methods, resulting in valid, reproducible data.

Matrix spike and *matrix spike duplicates* are used to determine whether the sample matrix (e.g., water, soil, air, vegetation, bone, or oil) adversely affected the sample analysis. A spike is a known amount of analyte added to a sample. Matrix spikes are performed at a rate specified by each environmental program’s DQOs. The rate is typically one per 20 samples collected per project. No significant matrix effects were observed in 2014 for routine matrices such as water and soil. Non-routine matrices, such as oil, exhibited the expected matrix issues.

9.2.3 TRACKING AND DATA MANAGEMENT

Most environmental monitoring samples and analytical results were tracked in BNL’s Environmental Information Management System (EIMS), a database system used to store, manage, verify, protect, retrieve, and archive BNL’s environmental data. A small number of environmental samples that were not tracked in the EIMS were analyzed at a contract analytical laboratory, Chemtex Lab, which cannot produce the electronic data deliverables needed to enter the data into the EIMS. Tracking is initiated when a sample is recorded on a COC form. Copies of the COC forms and supplemental forms are provided to the project manager or the sample coordinator and forwarded to the data coordinator to be entered into the EIMS. Each contract analytical laboratory also maintains its own internal sample tracking system.

Following sample analysis, the contract analytical laboratory provides the results to the project manager or designee and, when applicable, to the validation subcontractor. Once results of the analyses are entered into the EIMS, reports can be generated by project personnel and DOE Brookhaven Site Office staff using a web-based data query tool.

9.3 SAMPLE ANALYSIS

In 2014, environmental samples were analyzed

by six contract analytical laboratories, whose selection is discussed in Section 9.3.1. All samples were analyzed according to EPA-approved methods or by standard industry methods where no EPA methods are available. In addition, field sampling technicians performed field monitoring for parameters such as conductivity, dissolved oxygen, pH, temperature, and turbidity.

9.3.1 Qualifications

BNL used the following contract analytical laboratories for analysis of environmental samples in 2014:

- American Radiation Services (ARS) in Port Allen, Louisiana, for radiological analyses
- Chemtex Lab in Port Arthur, Texas, for select nonradiological analytes.
- General Engineering Lab (GEL) in Charleston, South Carolina, for radiological and nonradiological analytes.
- PACE Lab in Melville, New York, for non-radiological analytes.
- Test America (TA), based in St. Louis, Missouri, for radiological and nonradiological analytes.

The process of selecting contract analytical laboratories involves the following factors: 1) their record on performance evaluation (PE) tests, 2) their contract with the DOE Integrated Contract Procurement Team, 3) pre-selection bidding, and 4) their adherence to their own QA/QC programs, which must be documented and provided to BNL. Routine QC procedures that laboratories must follow, as discussed in Section 9.5, include daily instrument calibrations, efficiency and background checks, and standard tests for precision and accuracy. All the laboratories contracted by BNL in 2014 were certified by the New York State Department of Health (NYSDOH) for the relevant analytes, where such certification existed. The laboratories also were subject to PE testing and DOE-sponsored audits (see Section 9.7).

9.4 VERIFICATION AND VALIDATION OF ANALYTICAL RESULTS

Environmental monitoring data are subject to data verification and, in certain cases, data validation, when the data quality objectives of the

project require this step. For example, ground-water samples undergo data verification, whereas analytical results for specific waste streams undergo a full validation.

The data verification process involves checking for common errors associated with analytical data. The following criteria can cause data to be rejected during the data verification process:

- *Holding time missed* – The analysis is not initiated or the sample is not extracted within the time frame required by EPA or by the contract.
- *Incorrect test method* – The analysis is not performed according to a method required by the contract.
- *Poor recovery* – The compounds or radioisotopes added to the sample before laboratory processing are not recovered at the recovery ratio required by the contract.
- *Insufficient QA/QC data* – Supporting data received from the contract analytical laboratory are insufficient to allow validation of results.
- *Incorrect minimum detection limit (MDL)* – The contract analytical laboratory reports extremely low levels of analytes as “less than minimum detectable,” but the contractually required limit is not used.
- *Invalid chain-of-custody* – There is a failure to maintain proper custody of samples, as documented on COC forms.
- *Instrument failure* – The instrument does not perform correctly.
- *Preservation requirements not met* – The requirements identified by the specific analytical method are not met or properly documented.
- *Contamination of samples from outside sources* – Possible sources include sampling equipment, personnel, and the contract analytical laboratory.
- *Matrix interference* – Analysis is affected by dissolved inorganic/organic materials in the matrix.

Data validation involves a more extensive process than data verification. Validation includes all the verification checks, as well as checks for less common errors, including

instrument calibration that was not conducted as required, internal analyte standard errors, transcription errors, and calculation errors. The amount of data checked varies, depending on the environmental media and on the DQOs for each project. Data for some projects, such as long-term groundwater monitoring, may require only verification. Data from some waste streams receive the more rigorous validation testing, performed on 20 to 100 percent of the analytical results. The results of the verification or validation process are entered into the EIMS.

9.4.1 Checking Results

Nonradiological data analyzed in 2014 were verified and/or validated, when project DQOs required, using BNL EM-SOPs and EPA contract laboratory program guidelines (EPA 2012, EPA 2013). Radiological packages were verified and validated using BNL and DOE guidance documents (BNL 2012b). During 2014, the verifications were conducted using a combination of manually checking hard copy data packages and the use of a computer program developed at the Laboratory to verify that the information reported electronically is stored in the EIMS.

9.5 CONTRACT ANALYTICAL LABORATORY QA/QC

In 2014, procedures for calibrating instruments, analyzing samples, and assessing QC were consistent with EPA methodology. QC checks performed included: analyzing blanks and instrument background; using Amersham Radiopharmaceutical Company or National Institute for Standards and Technology (NIST) traceable standards; and analyzing reference standards, spiked samples, and duplicate samples. Analytical laboratory contracts specify analytes, methods, required detection limits, and deliverables, which include standard batch QA/QC performance checks. As part of the laboratory selection process, candidate laboratories are required to provide BNL with copies of their QA/QC manuals and QA program plans.

When discrepancies were found in field sampling designs, documented procedures, COC forms, data analyses, data processing systems, and QA software, or when failures in PE testing

occur, nonconformance reports are generated. Following investigation into the root causes, corrective actions are taken and tracked to closure.

9.6 PERFORMANCE OR PROFICIENCY EVALUATIONS

Four of the contract analytical laboratories (GEL, TA, PACE, and ARS) participated in several national and state PE testing programs in 2014. Chemtex Lab did not participate in PE testing because there is no testing program for the specific analytes Chemtex analyzed for BNL (tolytriazole, polypropylene glycol monobutyl ether, and 1,1-hydroxyethylidene diphosphonic acid). Each of the participating laboratories took part in at least one testing program, and several laboratories participated in multiple programs. Results of the tests provide information on the quality of a laboratory's analytical capabilities. The testing was conducted by Environmental Resource Associates (ERA), the DOE required Mixed Analyte Performance Evaluation Program (MAPEP), Resource Technology Corporation (RTC), Phenova, and NYSDOH Environmental Laboratory Accreditation Program (ELAP). The results from these tests are summarized in Section 9.6.1.

9.6.1 Summary of Test Results

In Figures 9-2 and 9-3, results are plotted as percentage scores that were "Acceptable," "Warning (But Acceptable)," or "Not Acceptable." A Warning (But Acceptable) is considered by the testing organization to be "satisfactory." An "average overall satisfactory" score is the sum of results rated as Acceptable and those rated as Warning (But Acceptable), divided by the total number of results reported. A Not Acceptable rating reflects a result that is greater than three standard deviations from the known value—a criterion set by the independent testing organizations.

Figure 9-2 summarizes radiological performance scores in the ERA, MAPEP, and ELAP programs. GEL, TA, and ARS had average overall satisfactory scores of 98, 93, and 100 percent, respectively. Additional details about the radiological assessments are discussed in Section 9.6.1.1.

Figure 9-3 summarizes the nonradiological performance results of three of the four participating laboratories (GEL, Pace, and TA) in the ERA, RTC, MAPEP, Phenova, and ELAP tests. For nonradiological tests, the average overall satisfactory results ranged from 97 to 98 percent for the three laboratories. Additional details on nonradiological evaluations are discussed in Section 9.6.1.2.

9.6.1.1 Radiological Assessments

Because ARS only analyzed tritium in water samples during 2014, only PE results for tritium were reviewed. GEL and TA participated in the ERA and MAPEP radiological PE studies. Of GEL's tests on radiological samples, 98 percent were in the Acceptable range and 93 percent of TA's tests were Acceptable. TA and ARS participated in the ELAP evaluations; 95 percent of TA's ELAP tests on radiological samples were in the Acceptable range and 100 percent of ARS's ELAP test results were in the Acceptable range.

9.6.1.2 Nonradiological Assessments

During 2014, PACE participated in the NYS-DOH ELAP evaluations of performance on tests of nonpotable water, potable water, and solid wastes. NYSDOH found 98 percent of PACE's nonradiological tests to be in the Acceptable range. GEL participated in the ERA water supply and water pollution studies. ERA found that 99 percent of GEL's tests were in the Acceptable range. TA and GEL participated in the MAPEP water supply and water pollution studies. MAPEP found that 97 percent of TA's results were in the Acceptable range, while 98 percent of GEL's results were in the Acceptable range. TA and GEL participated in the Phenova Soil/Hazardous Waste and Water Pollution proficiency testing programs. Phenova found that 97 percent of TA's results were in the Acceptable range, while 98 percent of GEL's results were in the Acceptable range. GEL also participated in RTC nonradiological evaluations, which showed that 93 percent of GEL's results were in the Acceptable range.

9.7 AUDITS

As part of DOE's Integrated Contract Procurement Team Program, TA, GEL, and ARS were

audited during 2014 (DOE 2014a,b,c). During the audits, errors are categorized into Priority I and Priority II findings. Priority I status indicates a problem that can result in unusable data or a finding that the contract analytical laboratory cannot adequately perform services for DOE. Priority II status indicates problems that do not result in unusable data and do not indicate that the contract analytical laboratory cannot adequately perform services for DOE (DOE 2002). There were no Priority I findings during 2014 that affected samples analyzed for BNL.

The results of the TA audit included two Priority I findings and twelve Priority II findings. The first Priority I finding included failing MAPEP PT tests for Iron-55 in soil and Nickel-63 in water matrices. The second Priority I finding was for failing the ERA PT evaluation for Americium-241 in soil by alpha spectroscopy. TA did not perform the analyses mentioned in the Priority I findings for BNL during 2014. The Priority II findings were in the following departments: three in Quality Assurance Management Systems, four in the Data Quality for Organic Analyses, one in the Inorganic and Wet Chemistry Department, three in Data Quality for Radionuclide Analyses, and one in Hazardous and Radioactive Materials Management.

The results of the GEL audit included 11 Priority II findings. The Priority II findings were in the following departments: one in the Quality Assurance Department and one in Data Quality for Radiochemistry Analyses.

The results of the ARS audit included 10 Priority II findings. The Priority II findings were in the following departments: two Priority II findings in the Quality Assurance Department, one in Data Quality for Inorganic and Wet Chemistry Analyses, four in Data Quality for Radiochemistry Analyses, and three in Hazardous and Radioactive Materials Management.

As part of the BNL quality control process, PACE is periodically audited (approximately every 5 years) to assure that their technical and environment, safety, and health programs meet BNL requirements. BNL staff conducted the last audit in September 2013 and issued its final report in October 2013 (BNL 2013). During the audit, four minor nonconformances were noted.

CHAPTER 9: QUALITY ASSURANCE

Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.

Note that the Acceptable scores and the Warning (But Acceptable) scores combined constitute the "overall satisfactory" category referred to in the text of this chapter.

Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.

The nonconformances were related to record keeping and housekeeping. Based on the audits, the analytical laboratories met DOE and BNL criteria for Acceptable status.

9.8 CONCLUSION

Based on the data validations, data verifications, and results of the independent PE assessments, the chemical and radiological results reported in this 2014 Site Environmental Report are of acceptable quality.

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Acronyms and Abbreviations

These acronyms and abbreviations reflect the typical manner in which terms are used for this specific document and may not apply to all situations. Items with an asterisk (*) are described in the glossary of technical terms, which follows this list.

ACTS	DOE Academies Creating Teacher Scientists	CFC-11	an ozone-depleting refrigerant
AFYs	Alternative Fuel Vehicles	cfm, cfs	cubic feet per minute, per second
AEC	Atomic Energy Commission	CFN	Center for Functional Nanomaterials
AGS	Alternating Gradient Synchrotron	CFR	U.S. Code of Federal Regulations
ALARA*	"As Low As Reasonably Achievable"	Ci*	curie
AMSL	above mean sea level	CO	certificate to operate
AMU	atomic mass unit	COC*	chain-of-custody
AOC*	area of concern	CRM	Cultural Resource Management
APG	Analytical Products Group	CRMP	Cultural Resource Management Plan
ARARs	Applicable, Relevant, and Appropriate Requirements	Cs	cesium
ARPA*	Archeological Resource Protection Act	CSF	Central Steam Facility
ARRA	American Recovery and Reinvestment Act	CTN	Center for Transitional Neuroimaging
AS/SVE*	air sparging/soil vapor extraction	CVO	Contractor Vendor Orientation
AST	aboveground storage tank	CWA*	Clean Water Act
AWQS	Ambient Water Quality Standards	CY	calendar year
BAF	Booster Applications Facility	D ₂ O*	heavy water
BGD	belowground duct	DAC	Derived Air Concentration
BGRR	Brookhaven Graphite Research Reactor	DCA	1,1-dichloroethane
BHSO	DOE Brookhaven Site Office	DCE	1,1-dichloroethylene
BLIP	Brookhaven Linac Isotope Producer	DCG*	derived concentration guide
BMRR	Brookhaven Medical Research Reactor	D&D	decontamination and decommissioning
BNL	Brookhaven National Laboratory	DDD	dichlorodiphenyldichloroethane
BOD*	biochemical oxygen demand	DDE	dichlorodiphenyldichloroethylene
Bq*	becquerel	DDT	dichlorodiphenyltrichloroethane
Bq/g	becquerel per gram	DMR	Discharge Monitoring Report
Bq/L	becquerel per liter	DOE*	U.S. Department of Energy
BRAHMS	Broad Range Hadron Magnetic Spectrometer	DOE CH	DOE Chicago Operations Office
BSA	Brookhaven Science Associates	DQO	Data Quality Objective
Btu	British thermal units	DSA	Documented Safety Analysis
CAA*	Clean Air Act	DSB	Duct Service Building
CAAA*	CAA Amendments (1990)	DUV – FEL	Deep UltraViolet – Free Electron Laser
CAC	Community Advisory Council	DWS	Drinking Water Standards
CAP	Clean Air Act Assessment Package	EA*	Environmental Assessment
CBS	chemical bulk storage	EBIS	Electron Beam Ion Source
CCR	Consumer Confidence Report	ECM	Energy Conservation Measures
CCWF	Central Chilled Water Facility	EDB*	ethylene dibromide
CEDR	Consolidated Energy Data Report	EDE*	Effective Dose Equivalent
CEGPA	Community, Education, Government and Public Affairs	EDTA	ethylenediaminetetraacetic acid
CERCLA*	Comprehensive Environmental Response, Compensation and Liability Act	EE/CA	Engineering Evaluation/Cost Analysis
Cf-252	californium-252	EE-IOCPA	Energy Employees Occupational Illness Compensation Program Act
		EIMS*	Environmental Information Management System
		EISA	Energy Independence and Security Act

APPENDIX A: GLOSSARY

ELAP	Environmental Laboratory Approval Program	H2M	H2M Labs, Inc.
EML	Environmental Measurements Laboratory	HEPA	high efficiency particulate air
EMP	Environmental Monitoring Plan	HFBR	High Flux Beam Reactor
EMS*	Environmental Management System	HFCs	Hydrofluorocarbons
EO	Executive Order	HITL	Heavy Ion Transfer Line
EPA*	U.S. Environmental Protection Agency	HPRS	Health Physics Reporting System
EPCRA*	Emergency Planning and Community Right-to-Know Act	HPSB	High Performance and Sustainable Buildings
EPEAT	Electronic Product Environmental Assessment Tool	HSS	Health, Safety and Security
EPD	Environmental Protection Division	HTO	tritiated water (liquid or vapor)
EPP	Environmentally Preferable Products	HVAC	heating/ventilation/air conditioning
ERP	Environmental Restoration Projects	HWMF	Hazardous Waste Management Facility
ERA	Environmental Resource Associates	I	Iodine
ERD	Environmental Restoration Division	IAEA	International Atomic Energy Agency
ES*	environmental surveillance	IAG	Interagency Agreement
ESPC	Energy Savings Performance Contract	IC	ion chromatography
ESR	Experimental Safety Review	ICP/MS	inductively coupled plasma/mass spectrometry
ES&H	Environment, Safety, and Health	IGA	Investment Grade Audit
ESA*	Endangered Species Act	ISB	Interdisciplinary Science Building
ESH&Q	Environment, Safety, Health, and Quality Directorate	ISMS	Integrated Safety Management System
ESPC	Energy Savings Performance Contract	ISO*	International Organization for Standardization
ESSH	Environmental Safety, Security and Health	K	potassium
FaST	Facility and Student Teams Program	kBq	kilobecquerels (1,000 Bq)
FAMS	Facility area monitors	KeV	kilo (thousand) electron volts
FEMP	Federal Emergency Management Program	Kr	kryptonite
FERN	Foundation for Ecological Research in the Northeast	kWh	kilowatt hours
FFCA*	Federal Facilities Compliance Act	LDR	Land Disposal Restriction
FFA	Federal Facilities Agreement	LED	light emitting diode
FHWMF	Former Hazardous Waste Management Facility	LEED	Leadership in Energy and Environmental Design
FIFRA*	Federal Insecticide, Fungicide, and Rodenticide Act	LIE	Long Island Expressway
FM	Facility Monitoring	LIMS	Laboratory Information Management System
FRP	Facility Response Plan	Linac	Linear Accelerator
FWS*	U.S. Fish & Wildlife Service	LIPA	Long Island Power Authority
FY	fiscal year	LISF	Long Island Solar Farm
GBq	giga (billion or E+09) becquerel	LSTPD	Laboratory Science Teacher Professional Development
GAB	gross alpha and beta	LTRA	Long Term Remedial Action
GC/ECD	gas chromatography/electron capture detector	mA	milli-amperes
GC/MS	gas chromatography/mass spectrometry	MACT	Maximum Available Control Technology
GDS	Groundwater Discharge Standard	MAPEP	Mixed Analyte Performance Evaluation Program
GEL	General Engineering Laboratory, LLC	MAR	Materials-at-risk
GeV	giga (billion) electron volts	MCL	maximum contaminant level
gge	gas gallon equivalent	MDL*	minimum detection limit
GHG	Greenhouse Gas	MEI*	maximally exposed individual
GIS	Geographical Information System	MEOSI	maximally exposed off-site individual
GPG	Groundwater Protection Group	MeV	million electron volts
GSF	gross square feet	MGD	million gallons per day
GWh	gigawatt hour	mg/L	milligrams per liter
GWP	Global warming potential	MMBtu	million British thermal units
		MOA	Memorandum of Agreement
		MPF	Major Petroleum Facility

APPENDIX A: GLOSSARY

MPN	most probable number	NYSHPO	NYS Historic Preservation Office
MPO	Modernization Project Office	O ₃ *	ozone
mrem	milli (thousandth of a) rem	O&M	Operation and Maintenance
MRI	Magnetic Resonance Imaging	ODS	ozone-depleting substances
MRC	Medical Research Center	OFIs	opportunities for improvement
MSL*	mean sea level	OHSAS	Occupational Health and Safety Assessment Series
mSv	millisievert	OMC	Occupational Medical Clinic
MTBE	methyl tertiary butyl ether	ORC	oxygen-releasing compound
MW	megawatt	ORNL	Oak Ridge National Laboratory
µg/L	micrograms per liter	ORPS*	Occurrence Reporting and Processing System
NA	not analyzed	OSHA	Occupational Health and Safety Administration
NCRP	National Council on Radiation Protection and Measurements	OSSP	Open Space Stewardship Program
ND	not detected	OU*	operable unit
NEAR	Neighbors Expecting Accountability and Remediation	P2*	pollution prevention
NELAC	National Environmental Laboratory Accreditation Conference	PAAA*	Price-Anderson Act Amendment
NELAP	National Environmental Laboratory Accreditation Program	PAF	Process Assessment Form
NEPA*	National Environmental Policy Act	Pb	lead
NESHAPs*	National Emission Standards for Hazardous Air Pollutants	PBT	persistent, bioaccumulative, and toxic
ng/J	nano (one-billionth) gram per Joule	PCBs*	polychlorinated biphenyls
NHPA*	National Historic Preservation Act	PCE	tetrachloroethylene (or perchloroethylene)
NIST	National Institute for Standards and Technology	pCi/g	picocuries per gram
nm	nanometer	PE	performance evaluation
NNSS	Nevada National Security Site	PET	positron emission tomography
NO ₂	nitrogen dioxide	PFCs	Perfluorocarbons
NOV	Notice of Violation	PIC	potential impact category
NO _x *	nitrogen oxides	ppb	parts per billion
NOEC	no observable effect concentration	ppm	parts per million
NPDES	National Pollutant Discharge Elimination System	PPTRS	Pollution Prevention Tracking System
NR	not required	PRAP	Proposed Remedial Action Plan
NRMP	Natural Resource Management Plan	PUE	Power Utilization Effectiveness
NS	not sampled	PV	photovoltaic
NSERC	Northeast Solar Energy Research Center	QA*	quality assurance
NSF-ISR	NSF-International Strategic Registrations, Ltd.	QAPP	Quality Assurance Program Plan
NSLS	National Synchrotron Light Source	QC*	quality control
NSLS-II	National Synchrotron Light Source II	QCU	quantum chromodynamics
NSPS	new source performance standards	QM	Quality Management
NSRC	Nanoscale Science Research Centers	R-11 (etc.)	ozone-depleting refrigerant
NSRL	NASA Space Radiation Laboratory	RA*	removal action
NT	not tested	RACT	Reasonably Available Control Technology
NTS	Nevada Test Site	RATA	Relativistic accuracy test
NYCRR*	New York Codes, Rules, and Regulations	RCRA*	Resource Conservation and Recovery Act
NYISO	New York Independent System Operator	RD/RA	Remedial Design/Remedial Action
NYPA	New York Power Authority	REC	Renewable Energy Credit
NYS	New York State	RF	resuspension factor
NYSDEC	NYS Department of Environmental Conservation	RHIC	Relativistic Heavy Ion Collider
NYSDOH	NYS Department of Health	ROD*	Record of Decision
		RPD	relative percent difference
		RSB	Research Support Building
		RTF	Radiation Therapy Facility

APPENDIX A: GLOSSARY

RWMB	Radioactive Waste Management Basis	TBq	tera (trillion, or E+12) becquerel
RWP	Radiological Work Permit	TCA	1,1,1-trichloroethane
S&M	surveillance and maintenance	TCAP	Transportation Safety and Operations Compliance Assurance Process
SARA*	Superfund Amendments and Reauthorization Act	TCE*	trichloroethylene
SBMS*	Standards Based Management System	TCLP	toxicity characteristic leaching procedure
SCDHS	Suffolk County Department of Health Services	TEAM	Transformational Energy Action Management
SCR	Special Case Resource	TED	Total Effective Dose
SCSC	Suffolk County Sanitary Code	TEDE	Total Effective Dose Equivalent
SDL	Source Development Laboratory	TKN	Total Kjeldahl nitrogen
SDWA*	Safe Drinking Water Act	TLD*	thermoluminescent dosimeter
SER	Site Environmental Report	TPL	Target Processing Laboratory
SI	International System (measurement units)	TRE	Toxic Reduction Evaluation
SNS	standard not specified	TRI	Toxic Release Inventory
SO ₂	sulfur dioxide	TSCA*	Toxic Substances Control Act
SOP	standard operating procedure	TVDG	Tandem Van de Graaff
SPCC	Spill Prevention Control and Countermeasures	TVOC*	total volatile organic compounds
SPDES*	State Pollutant Discharge Elimination System	UESC	Utility Energy Services Contract
Sr	strontium	UIC*	underground injection control
SSP	Site Sustainability Plan	UST*	underground storage tank
SSPP	Strategic Sustainability Performance Plan	VOC*	volatile organic compound
STAR	Solenoid Tracker at RHIC	VUV*	very ultraviolet
STEM	Scanning Transmission Electron Microscope	WAC	waste acceptance criteria
STL	Severn Trent Laboratories, Inc.	WBS	Work Breakdown Structure
STP	Sewage Treatment Plant	WCPP	Waste Certification Program Plan
SU	standard unit	WCF	Waste Concentration Facility
SUNY	State University of New York	WET	Whole Effluent Toxicity
Sv*	sievert; unit for assessing radiation dose risk	WLA	Waste Loading Area
SVE*	soil vapor extraction	WM	Waste Management
SVOC*	semivolatile organic compound	WMF	Waste Management Facility
t _{1/2} *	half-life	WTP	Water Treatment Plant
TAG	Technical Advisory Group		

Technical Terms

These definitions reflect the typical manner in which the terms are used for this specific document and may not apply to all situations. Bold-face words in the descriptions are defined in separate entries.

A

AA (atomic absorption) – A spectroscopy method used to determine the elemental composition of a sample. In this method, the sample is vaporized and the amount of light it absorbs is measured.

accuracy – The degree of agreement of a measurement with an accepted reference or true value. It can be expressed as the difference between two values, as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

activation – The process of making a material radioactive by bombardment with neutrons, protons, or other high energy particles.

activation product – A material that has become radioactive by bombardment with neutrons, protons, or other high energy particles.

activity – Synonym for radioactivity.

Administrative Record – A collection of documents established in compliance with **CERCLA**. Consists of information the CERCLA lead agency uses in its decision on the selection of response actions. The Administrative Record file should be established at or near the facility and made available to the public. An Administrative Record can also be the record for any enforcement case.

aerobic – An aerobic organism is one that lives, acts, or occurs only in the presence of oxygen.

aerosol – A gaseous suspension of very small particles of liquid or solid.

ALARA (As Low As Reasonably Achievable) – A phrase that describes an approach to minimize exposures to individuals and minimize releases of radioactive or other harmful material to the **environment** to levels as low as social, technical, economic, practical, and public policy considerations will permit. ALARA is not a dose limit, but a process with a goal to keep dose levels as far below applicable limits as is practicable.

alpha radiation – The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of only an inch or so. Despite its low penetration ability, alpha radiation is densely ionizing and therefore very damaging when ingested or inhaled. Naturally occurring radioactive sources such as radon emit alpha radiation.

air stripping – A process for removing **VOCs** from contaminated water by forcing a stream of air through the water in a vessel. The contaminants evaporate into the air stream. The air may be further treated before it is released into the atmosphere.

ambient air – The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources.

analyte – A constituent that is being analyzed.

anneal – To heat a material and then cool it. In the case of thermoluminescent dosimeters (TLDs), this is done to reveal the amount of radiation the material had absorbed.

anion – A negatively charged ion, often written as a superscript negative sign after an element symbol, such as Cl⁻.

anthropogenic – Resulting from human activity; anthropogenic radiation is human-made, not naturally occurring.

AOC (area of concern) – Under **CERCLA**, this term refers to an area where releases of hazardous substances may have occurred or a location where there has been a release or threat of a release of a hazardous substance, pollutant, or contaminant (including **radionuclides**). AOCs may include, but need not be limited to, former spill areas, landfills, surface impoundments, waste piles, land treatment units, transfer stations, wastewater treatment units, incinerators, container storage areas, scrap yards, cesspools, tanks, and associated piping that are known to have caused a release into the environment or whose integrity has not been verified.

aquifer – A water-saturated layer of rock or soil below the ground surface that can supply usable quantities of **groundwater** to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

ARPA (Archaeological Resources Protection Act) This law, passed in 1979, has been amended four times. It protects any material remains of past human life or activities that are of archaeological interest. Known *and potential* sites of interest are protected from uncontrolled excavations and pillage, and artifacts found on public and Indian lands are banned from commercial exchange.

AS/SVE (air sparging/soil vapor extraction) – A method of extracting **volatile organic compounds** from the **groundwater**, in place, using compressed air. (In contrast, air stripping occurs in a vessel.) The vapors are typically collected using a soil vapor extraction system.

B

background – A sample or location used as reference or control to compare BNL analytical results to those in areas that could not have been impacted by BNL operations.

background radiation – **Radiation** present in the environment as a result of naturally occurring radioactive materials in the Earth, cosmic radiation, or human-made radiation sources, including fallout.

beta radiation – Beta radiation is composed of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is more penetrating than alpha radiation, but it may be stopped by materials such as aluminum or Lucite™ panels. Naturally occurring radioactive elements such as potassium-40 emit beta radiation.

blank – A sample (usually reagent-grade water) used for quality control of field sampling methods, to demonstrate that cross contamination has not occurred.

blowdown – Water discharged from either a boiler or cooling tower in order to prevent the build-up of inorganic matter within the boiler or tower and to prevent scale formation (i.e., corrosion).

BOD (biochemical oxygen demand) – A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

Bq (becquerel) – A quantitative measure of **radioactivity**. This alternate measure of activity is used internationally and with increasing frequency in the United States. One Bq of activity is equal to one nuclear decay per second.

bremsstrahlung – Translates as “fast braking” and refers to electromagnetic radiation produced by the sudden retardation of a charged particle in an intense electric field.

C

CAA (Clean Air Act), CAA Amendments (CAAA) – The original Clean Air Act was passed in 1963, but the U.S. air pollution control program is based on the 1970 version of the law. The 1990 Clean Air Act Amendments (CAAA) are the most far-reaching revisions of the 1970 law. In common usage, references to the CAA typically mean to the 1990 amendments. (*source*: EPA’s “Plain English Guide to the Clean Air Act” glossary, accessed 3-7-05)

caisson – A watertight container used in construction work under water or as a foundation.

cap – A layer of natural or synthetic material, such as clay or gunite, used to prevent rainwater from penetrating and spreading contamination. The surface of the cap is generally mounded or sloped so water will drain off.

carbon adsorption/carbon treatment – A treatment system in which contaminants are removed from **groundwater**, surface water, and air by forcing water or air through tanks containing activated carbon (a specially treated material that attracts and holds or retains contaminants).

carbon tetrachloride – A poisonous, nonflammable, colorless liquid, CCl₄.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) – Pronounced “sir-klah” and commonly known as Superfund, this law was enacted by Congress on December 11, 1980. It created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified.

The law authorizes two kinds of response actions: short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response, and long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on EPA’s National Priorities List (NPL). CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986, accessed 03-7-05)

CFR (Code of Federal Regulations) – A codification of all regulations developed and finalized by federal agencies in the Federal Register. The CFR is arranged by “title,” with Title 10 covering energy- and radiation-related issues, and Title 40 covering protection of the environment. Subparts within the titles are included in citations, as in “40 CFR Subpart H.”

characterization – Facility or site sampling, monitoring, and analysis activities to determine the extent and nature of contamination. Characterization provides the basis of necessary technical information to select an appropriate cleanup alternative.

Ci (curie) – A quantitative measure of radioactivity. One Ci of activity is equal to 3.7E+10 decays per second. One curie has the approximate activity of 1 gram of radium. It is named after Marie and Pierre Curie, who discovered radium in 1898.

Class GA groundwater – New York State Department of Environmental Conservation classification for high quality groundwater, where the best intended use is as a source of drinking water supply.

closure – Under **RCRA** regulations, this term refers to a hazardous or solid waste management unit that is no longer operating and where potential hazards that it posed have been addressed (through clean up, immobilization, capping, etc.) to the satisfaction of the regulatory agency.

CO₂ equivalent (CO₂e) – The universal unit of measurement to indicate the GWP of each of the six GHGs expressed in terms of the GWP of one unit of CO₂. It is used to evaluate the release (or the avoided release) of differ-

ent GHG emissions against a common basis, and is commonly expressed as metric tons carbon dioxide equivalent (MtCO₂e), which is calculated by multiplying the metric tons of GHG by its GWP.

COC (chain-of-custody) – A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

cocktail – a mixture of chemicals used for **scintillation** counting.

collective Effective Dose Equivalent – A measure of health risk to a population exposed to radiation. It is the sum of the **EDEs** of all individuals within an exposed population, frequently considered to be within 50 miles (80 kilometers) of an environmental release point. It is expressed in **person-rem** or **person-sievert**.

Committed Effective Dose Equivalent – The total **EDE** received over a 50-year period following the internal deposition of a **radionuclide**. It is expressed in **rem**s or **sieverts**.

composite sample – A sample of an environmental medium containing a certain number of sample portions collected over a period of time, possibly from different locations. The constituent samples may or may not be collected at equal time intervals over a predefined period of time, such as 24 hours.

confidence interval – A numerical range within which the true value of a measurement or calculated value lies. In the SER, radiological values are shown with a 95 percent confidence interval: there is a 95 percent probability that the true value of a measurement or calculated value lies within the specified range. *See also* “Uncertainty” discussion in Appendix B.

conservative – Estimates that err on the side of caution because all possibly deleterious components are included at generous or high values.

contamination – Unwanted radioactive and/or hazardous material that is dispersed on or in equipment, structures, objects, air, soil, or water.

control – *See background*.

cooling water – Water used to cool machinery and equipment. *Contact* cooling water is any wastewater that contacts machinery or equipment to remove heat from the metal; *noncontact* cooling water has no direct contact with any process material or final product. *Process wastewater* cooling water is water used for cooling that may have become contaminated through contact with process raw materials or final products.

cover boards – Sheets of plywood placed on the ground near ponds to serve as attractive habitat for salamanders, as part of a population study.

curie – *See Ci*.

CWA (Clean Water Act) – Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments

of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. It established the basic structure for regulating discharges of pollutants into the waters of the United States, giving **EPA** the authority to implement pollution control programs such as setting wastewater standards for industry. The CWA also continued requirements to set water quality standards for all contaminants in surface waters and made it unlawful for any person to discharge any pollutant from a **point source** into navigable waters unless a permit was obtained. The CWA also funded the construction of sewage treatment plants and recognized the need for planning to address the critical problems posed by **nonpoint source pollution**.

Revisions in 1981 streamlined the municipal construction grants process. Changes in 1987 phased out the construction grants program. Title I of the Great Lakes Critical Programs Act of 1990 put into place parts of the Great Lakes Water Quality Agreement of 1978, signed by the U.S. and Canada; the two nations agreed to reduce certain toxic pollutants in the Great Lakes. Over the years many other laws have changed parts of the CWA, accessed 03-7-05).

D

D₂O – *See heavy water*.

daughter, progeny – A given **nuclide** produced by radioactive decay from another nuclide (the “parent”). *See also radioactive series*.

DCG (derived concentration guide) – The concentration of a **radionuclide** in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation, absorption, or ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). The values were established in **DOE Order 5400.5**.

decay product – A **nuclide** resulting from the radioactive disintegration of a **radionuclide**, being formed either directly or as a result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.

decontamination – The removal or reduction of **radioactive** or hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques to achieve a stated objective or end condition.

disposal – Final placement or destruction of waste.

DOE (Department of Energy) – The federal agency that promotes scientific and technical innovation to support the national, economic, and energy security of the United States. DOE has responsibility for 10 national laboratories and for the science and research conducted at these laboratories, including Brookhaven National Laboratory.

DOE Order 231.1A – This order, Environment, Safety, and Health Reporting, is dated 8/19/03. It replaces the 1995 version, Order 231.1, as well as the “ORPS” order, DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information, dated 7/21/97, and Order 210.1, Performance Indicator..., dated 9/27/95.

DOE Order 450.1A – This order, Environmental Protection Program, is dated 6/04/08. It revises DOE Order 450.1, issued in January 2003, to incorporate and implement the new requirements of Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, issued in January 2007.

DOE Order 5400.5 – This order, Radiation Protection of the Public and the Environment, was first published by DOE in 1990 and was modified in 1993. It established the standards and requirements for operations of DOE and DOE contractors with respect to protecting the public and the **environment** against undue risk from radiation.

dose – See **EDE**.

dosimeter – A portable detection device for measuring exposure to ionizing radiation. See Chapter 8 for details.

downgradient – In the direction of **groundwater** flow from a designated area; analogous to “downstream.”

DQO (Data Quality Objective) – The Data Quality Objective (DQO) process was developed by EPA for facilities to use when describing their environmental monitoring matrices, sampling methods, locations, frequencies, and measured parameters, as well as methods and procedures for data collection, analysis, maintenance, reporting, and archiving. The DQO process also addresses data that monitor quality assurance and quality control.

drift fence – A stretch of temporary fencing to prevent an animal population from leaving the area, used at BNL as part of a population study.

dry weight – The dry weight concentration of a substance is after a sample is dried for analysis. Dry weight concentrations are typically higher than wet weight values.

D-waste – Liquid waste containing radioactivity.

E

EA (Environmental Assessment) – A report that identifies potentially significant effects from any federally approved or funded project that might change the physical **environment**. If an EA identifies a “significant” potential impact (as defined by NEPA), an Environmental Impact Statement (EIS) must be researched and prepared.

EDB (ethylene dibromide) – A colorless, nonflammable, heavy liquid with a sweet odor; slightly soluble in water. Although the U.S. Department of Health and Human Services has determined that ethylene dibromide may reasonably be anticipated to be a carcinogen, it is still used to treat felled logs for bark beetles; to control wax moths in beehives; as a chemical intermediary for dyes, resins, waxes, and gums; to spot-treat milling machinery; and to control Japanese beetles in ornamental plants.

EDE (Effective Dose Equivalent) – A value used to express the health risk from radiation exposure to tissue in terms of an equivalent whole body exposure. It is a “normalized” value that allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole-body exposure. The EDE equals the

sum of the doses to different organs of the body multiplied by their respective **weighting factors**. It includes the sum of the EDE due to radiation from sources external to the body and the committed effective dose equivalent due to the internal deposition of **radionuclides**. EDE is expressed in **rems** or **sieverts**.

effluent – Any liquid discharged to the environment, including stormwater **runoff** at a site or facility.

EIMS (Environmental Information Management System) – A database system used to store, manage, verify, protect, retrieve, and archive BNL’s environmental data.

EM (environmental monitoring) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

emissions – Any gaseous or particulate matter discharged to the atmosphere.

EMS (Environmental Management System) – The BNL EMS meets the requirements of the **ISO 14001 EMS standard**, with emphasis on compliance assurance, pollution prevention, and community outreach. An extensive environmental monitoring program is one component of BNL’s EMS.

environment – Surroundings (including air, water, land, natural resources, flora, fauna, and humans) in which an organization operates, and the interrelation of the organization and its surroundings.

environmental aspect – Elements of an organization’s activities, products, or services that can interact with the surrounding air, water, land, natural resources, flora, fauna, and humans.

environmental impact – Any change to the surrounding air, water, land, natural resources, flora, and fauna, whether adverse or beneficial, wholly or partially resulting from an organization’s activities, products, or services.

environmental media – Includes air, **groundwater**, surface water, soil, flora, and fauna.

environmental monitoring or surveillance – See **EM**.

EPA (U. S. Environmental Protection Agency) – The federal agency responsible for developing and enforcing environmental laws. Although state or local regulatory agencies may be authorized to administer environmental regulatory programs, EPA generally retains oversight authority.

EPCRA (Emergency Planning and Community Right-to-Know Act) – Also known as Title III of SARA, EPCRA was enacted by Congress as the national legislation on community safety, to help local groups protect public health, safety, and the environment from chemical hazards. To implement EPCRA, Congress required each state to appoint a State Emergency Response Commission (SERC). The SERCs were required to divide their states into Emergency Planning Districts and to name a Local Emergency Planning Committee for each district.

Broad representation by fire fighters, health officials, government and media representatives, community groups,

industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

ES (environmental surveillance) – Sampling for contaminants in air, water, sediment, soil, food stuffs, plants, and animals, either by directly measuring or by collecting and analyzing samples.

ESA (Endangered Species Act) – This provides a program for conserving threatened and endangered plants and animals and their habitats. The **FWS** maintains the list of 632 *endangered* species (326 are plants) and 190 *threatened* species (78 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Anyone can petition FWS to include a species on this list. The law prohibits any action, administrative or real, that results in a “taking” of a listed species or adversely affects habitat. Likewise, import, export, interstate, and foreign commerce of listed species are all prohibited. **EPA**’s decision to register pesticides is based in part on the risk of adverse effects on endangered species as well as environmental fate (how a pesticide will affect habitat). Under **FIFRA**, **EPA** can issue emergency suspensions of certain pesticides to cancel or restrict their use if an endangered species will be adversely affected.

evapotranspiration – A process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other aboveground tissue.

exposure – A measure of the amount of ionization produced by x-rays or gamma rays as they travel through air. The unit of radiation exposure is the roentgen (R).

F

fallout – Radioactive material, made airborne as a result of aboveground nuclear weapons testing, that has been deposited on the Earth’s surface.

FFCA (Federal Facility Compliance Act) – Formerly, the federal government maintained that it was not subject to fines and penalties under solid and hazardous waste law because of the doctrine of “sovereign immunity.” The State of Ohio challenged this in *Ohio v. the Department of Energy* (1990). The U.S. Circuit Court of Appeals found in favor of the State (June 11, 1990), writing that the federal government’s sovereign immunity is waived under both the **CWA** sovereign immunity provision and **RCRA**’s citizen suit provision. The Circuit Court decision was overturned by the Supreme Court on April 21, 1992, in *DOE v. Ohio*, which held that the waiver of sovereign immunity in **RCRA** and **CWA** is not clear enough to allow states to impose civil penalties directly. After the high court’s ruling, the consensus among lawmakers was that a double standard existed: the same government that developed laws to protect human health and the environment and required compliance in the private sector, was itself not assuming the burden of compliance. As a result, Congress enacted the **FFCA** (October 6, 1992, Pub. Law 102-386), which

effectively overturned the Supreme Court’s ruling. In the legislation Congress specifically waived sovereign immunity with respect to **RCRA** for federal facilities.

Under section 102, **FFCA** amends section 6001 of **RCRA** to specify that federal facilities are subject to “all civil and administrative penalties and fines, regardless of whether such penalties or fines are punitive or coercive in nature.” These penalties and fines can be levied by **EPA** or by authorized states. In addition, **FFCA** states that “the United States hereby expressly waives any immunity otherwise applicable to the United States.” Although federal agents, employees, and officers are not liable for civil penalties, they are subject to criminal sanctions. No departments, agencies, or instrumentalities are subject to criminal sanctions. Section 104 (1) and (2) require **EPA** to conduct annual **RCRA** inspections of all federal facilities.

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) – The primary focus of this law was to provide federal control of pesticide distribution, sale, and use. **EPA** was given authority under **FIFRA** not only to study the consequences of pesticide usage but also to require users (farmers, utility companies, and others) to register when purchasing pesticides. Through later amendments to the law, users also must take exams for certification as applicators of pesticides. All pesticides used in the U.S. must be registered (licensed) by **EPA**. Registration assures that pesticides will be properly labeled and that if used in accordance with specifications, will not cause unreasonable harm to the environment.

FS (feasibility study) – A process for developing and evaluating remedial actions using data gathered during the remedial investigation. The **FS** defines the objectives of the remedial program for the site and broadly develops remedial action alternatives, performs an initial screening of these alternatives, and performs a detailed analysis of a limited number of alternatives that remain after the initial screening stage.

FWS (U.S. Fish & Wildlife Service) – The U.S. Fish and Wildlife Service is the principal federal agency responsible for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the people of the United States. **FWS** manages the 95-million-acre National Wildlife Refuge System, which encompasses 544 national wildlife refuges, thousands of small wetlands, and other special management areas. It also operates 69 national fish hatcheries, 64 fishery resources offices, and 81 ecological services field stations. The agency enforces federal wildlife laws, administers the Endangered Species Act, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and helps foreign and Native American tribal governments with their conservation efforts. It also oversees the Federal Assistance Program, which distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies.

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fugitive source – Unanticipated sources of volatile hazardous air pollutants due to leaks from valves, pumps, compressors, relief valves, connectors, flanges, and various other pieces of equipment.

G

gamma radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than **alpha** or **beta** radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy – This analysis technique identifies specific **radionuclides**. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each nuclide, acting as a "fingerprint."

geotextile – A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose manner to form a blanket-like product.

grab sample – A single sample collected at one time and place.

Green Building – Construction that adheres to guidelines established by the Green Building Council, a coalition of leaders from across the building industry working to promote structures that are environmentally responsible, profitable, and healthy places to live and work.

greenhouse gas (GHG) – Carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).

global warming potential (GWP) – A factor describing the radiative forcing impact of one unit of a given GHG relative to one unit of CO₂.

groundwater – Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.

gunite – A mixture of cement, sand, and water sprayed over a mold to form a solid, impermeable surface. Formerly a trademarked name, now in general usage.

H

half-life (t_{1/2}) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

halon – An ozone-depleting fire suppressant; suffixes (-1301, etc.) indicate variants.

hazardous waste – Toxic, corrosive, reactive, or ignitable materials that can injure human health or damage the environment. It can be liquid, solid, or sludge, and include heavy metals, organic solvents, reactive compounds, and corrosive materials. It is defined and regulated by **RCRA**, Subtitle C.

heat input – The heat derived from combustion of fuel in a steam generating unit. It does not include the heat from preheated combustion air, recirculated flue gases, or the exhaust from other sources.

heavy water (D₂O) – A form of water containing deuterium, a nonradioactive isotope of hydrogen.

herpetofaunal – Relating to the study of reptiles.

hot cell – Shielded and air-controlled facility for the remote handling of radioactive material.

hydrofluorocarbons (HFCs) – One of six primary GHGs primarily used as refrigerants; a class of gases containing hydrogen, fluorine, and carbon, and possessing a range of GWP values from 12 to 11,700.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

I

inert – Lacking chemical or biological action.

influent – Liquid (such as stormwater runoff or wastewater) flowing into a reservoir, basin, or treatment plant.

intermittent river – A stream that dries up on occasion, usually as a result of seasonal factors or decreased contribution from a source such as a wastewater treatment plant.

ionizing radiation – Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. High doses of ionizing radiation may produce severe skin or tissue damage. *See also alpha, beta, gamma radiation; x-rays.*

ISO 14001 EMS standard – The International Organization for Standardization (ISO) sets standards for a wide range of products and management operations. Following the success of the ISO 9000 Standards for quality management, ISO introduced the 14000 series for environmental management. BNL was the first DOE Office of Science laboratory to obtain third-party registration to this globally recognized environmental standard.

isotope – Two or more forms of a chemical element having the same number of protons in the nucleus (the same atomic number), but having different numbers of neutrons in the nucleus (different atomic weights). Isotopes of a single element possess almost identical chemical properties.

L

leaching – The process by which soluble chemical components are dissolved and carried through soil by water or some other percolating liquid.

light water – As used in this document, tap water, possibly filtered.

liquid scintillation counter – An analytical instrument used to quantify tritium, carbon-14, and other beta-emitting **radionuclides**. *See also scintillation.*

M

matrix, matrices – The natural context (e.g., air, vegetation, soil, water) from which an environmental sample is collected.

MDL (minimum detection limit) – The lowest level to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDL are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

MEI (maximally exposed individual) – The hypothetical individual whose location and habits tend to maximize his/her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

metamorphic – In the state of changing from larval to mature forms.

mixed waste – Waste that contains both a hazardous waste component (regulated under Subtitle C of **RCRA**) and a radioactive component.

monitoring – The collection and analysis of samples or measurements of effluents and emissions for the purpose of characterizing and quantifying contaminants, and demonstrating compliance with applicable standards.

monitoring well – A well that collects **groundwater** for the purposes of evaluating water quality, establishing groundwater flow and elevation, determining the effectiveness of treatment systems, and determining whether administrative or engineered controls designed to protect groundwater are working as intended.

MSL (mean sea level) – The average height of the sea for all stages of the tide. Used as a benchmark for establishing groundwater and other elevations.

N

NEPA (National Environmental Policy Act) – Assures that all branches of government give proper consideration to the environment before any land purchase or any construction projects, including airports, buildings, military complexes, and highways. Project planners must assess the likely impacts of the project by completing an Environmental Assessment (EA) and, if necessary, an Environmental Impact Statement (EIS).

NESHAPs (National Emissions Standards for Hazardous Air Pollutants) – Standards that limit emissions from specific sources of air pollutants linked to serious health hazards. NESHAPs are developed by **EPA** under the CAA. Hazardous air pollutants can be chemical or radioactive. Their sources may be human-made, such as vehicles, power plants, and industrial or research processes, or natural, such as radioactive gas in soils.

neutrino – A small, neutral particle created as a result of particle decay. Neutrinos were believed to be massless, but recent studies have indicated that they have small, but finite,

mass. Neutrinos interact very weakly.

NHPA (National Historic Preservation Act) – With passage of the National Historic Preservation Act in 1966, Congress made the federal government a full partner and a leader in historic preservation. The role of the federal government is fulfilled through the National Park Service. State participation is through State Historic Preservation Offices. “Before 1966, historic preservation was mainly understood in one-dimensional terms: the proverbial historic shrine or Indian burial mound secured by lock and key—usually in a national park—set aside from modern life as an icon for study and appreciation. NHPA largely changed that approach, signaling a much broader sweep that has led to the breadth and scope of the vastly more complex historic preservation mosaic we know today.”

nonpoint source pollution – Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into **groundwater**. Nonpoint source pollution also includes adverse changes to the hydrology of water bodies and their associated aquatic habitats. After Congress passed the Clean Water Act in 1972, the nation’s water quality community emphasized **point source** pollution (coming from a discrete conveyance or location, such as industrial and municipal waste discharge pipes). Point sources were the primary contributors to the degradation of water quality then, and the significance of nonpoint source pollution was poorly understood. Today, nonpoint source pollution remains the largest source of water quality problems. It is the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

NO_x – Nitrogen oxides are gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced, for example, by the combustion of fossil fuels in vehicles and electric power plants. In the atmosphere, NO_x can contribute to the formation of smog, impair visibility, and have health consequences. NO_x are considered “criteria air pollutants” under the CAA.

nuclide – A species of atom characterized by the number of protons and neutrons in the nucleus.

NYCRR (New York Codes, Rules, and Regulations) The NYCRR primarily contains state agency rules and regulations adopted under the State Administrative Procedure Act. There are 22 Titles: one for each state department, one for miscellaneous agencies and one for the Judiciary. Title 6 addresses environmental conservation, so many references in the SER are to “6 NYCRR.”

O

O₃ – See ozone.

on site – The area within the boundaries of a site that is controlled with respect to access by the general public.

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opacity – Under the Clean Air Act (CAA), a measurement of the degree to which smoke (emissions other than water vapor) reduces the transmission of light and obscures the view of an object in the background.

ORPS (Occurrence Reporting and Processing System) A system for identifying, categorizing, notifying, investigating, analyzing, and reporting to DOE events or conditions discovered at the BNL site. It was originally established by DOE Order 232.1, which has been replaced by **DOE Order 231.1A**.

OU (operable unit) – Division of a contaminated site into separate areas based on the complexity of the problems associated with it. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action. They may also consist of any set of actions performed over time, or actions that are concurrent, but located in different parts of a site. An OU can receive specific investigation and a particular remedy may be proposed. A Record of Decision (**ROD**) is prepared for each OU.

outfall – The place where wastewater is discharged.

oxides of nitrogen (NO_x) – See NO_x.

ozone (O₃) – A very reactive type of oxygen formed naturally in the upper atmosphere which provides a shield for the earth from the sun's ultraviolet rays. At ground level or in the lower atmosphere, it is pollution that forms when oxides of nitrogen and hydrocarbons react with oxygen in the presence of strong sunlight. Ozone at ground level can lead to health effects and cause damage to trees and crops.

P

P2 (pollution prevention) – Preventing or reducing the generation of pollutants, contaminants, hazardous substances, or wastes at the source, or reducing the amount for treatment, storage, and disposal through recycling. Pollution prevention can be achieved through reduction of waste at the source, segregation, recycle/reuse, and the efficient use of resources and material substitution. The potential benefits of pollution prevention include the reduction of adverse environmental impacts, improved efficiency, and reduced costs.

PAAA (Price-Anderson Act Amendments) – The Price-Anderson Act (PAA) was passed in 1957 to provide for prompt compensation in the case of a nuclear accident. The PAA provided broad financial coverage for damage, injury, and costs, and required DOE to indemnify contractors. The amended act of 1988 (PAAA) extended indemnification for 15 years and required DOE to establish and enforce nuclear safety rules. The PAAA Reauthorization, passed in December of 2002, extended current indemnification levels through 2004. 10 CFR 820 and its Appendix A provide DOE enforcement procedure and policy.

Parshall flume – An engineered channel used to measure the flow rate of water. It was named after the inventor, who worked for the U.S. government as an irrigation research engineer.

PCBs (polychlorinated biphenyls) – A family of organic compounds used from 1926 to 1979 (when they were banned by **EPA**) in electrical transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into different and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process.

percent recovery – For analytical results, the ratio of the measured amount, divided by the known (spiked) amount, multiplied by 100.

perfluorocarbons (PFCs) – One of the six primary GHGs consisting of a class of gases containing carbon and fluorine typically emitted as by-products of industrial and manufacturing processes, and possessing GWPs ranging from 5,700 to 11,900.

permit – An authorization issued by a federal, state, or local regulatory agency. Permits are issued under a number of environmental regulatory programs, including **CAA**, **CWA**, **RCRA**, and **TSCA**. Permits grant permission to operate, to discharge, to construct, and so on. Permit provisions may include emission/effluent limits and other requirements such as the use of pollution control devices, monitoring, record keeping and reporting. Also called a “license” or “certificate” under some regulatory programs.

pH – A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, neutral solutions have a pH of 7, and basic solutions have a pH greater than 7 and up to 14.

plume – A body of contaminated **groundwater** or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

point source – Any confined and discrete conveyance (e.g., pipe, ditch, well, or stack) of a discharge.

pollutant – Any hazardous or radioactive material naturally occurring or added to an environmental medium, such as air, soil, water, or vegetation.

potable water – Water of sufficient quality for use as drinking water without endangering the health of people, plants, or animals.

precision – A statistical term describing the dispersion of data around a central value, usually represented as a variance, standard deviation, standard error, or confidence interval.

putrescible waste – Garbage that contains food and other organic biodegradable materials. There are special management requirements for this waste in 6 **NYCRR** Part 360.

Q

QA (quality assurance) – In environmental monitoring, any action to ensure the reliability of monitoring and measurement data. Aspects of QA include procedures, inter-laboratory comparison studies, evaluations, and documentation.

QC (quality control) – In environmental monitoring, the routine application of procedures to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

qualifier – A letter or series of letter codes in a graph or chart indicating that the associated value did not meet analytical requirements or was estimated.

quenching – Anything that interferes with the conversion of decay energy to electronic signal in the photomultiplier tubes of detection equipment, usually resulting in a reduction in counting efficiency.

R

R (roentgen) – A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. It is named after the German scientist Wilhelm Roentgen, who discovered x-rays.

RA (removal actions, “removals”) – Interim actions that are undertaken to prevent, minimize, or mitigate damage to the public health or environment that may otherwise result from a release or threatened release of hazardous substances, pollutants, or contaminants pursuant to **CERCLA**, and that are not inconsistent with the final remedial action. Under **CERCLA**, **EPA** may respond to releases or threats of releases of hazardous substances by starting an RA to stabilize or clean up an incident or site that immediately threatens public health or welfare. Removal actions are less comprehensive than *remedial* actions. However, removal actions must contribute to the efficiency of future remedial actions.

radiation – Some atoms possess excess energy, causing them to be physically unstable. Such atoms become stable when the excess energy is released in the form of charged particles or electromagnetic waves, known as radiation.

radiation event – A single detection of a charged particle or electromagnetic wave.

radioactive series – A succession of **nuclides**, each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member of the series is called the parent and the intermediate members are called daughters or progeny.

radioactivity – The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as “activity.”

radionuclide – A radioactive element characterized by the number of protons and neutrons in the nucleus. There are several hundred known radionuclides, both artificially produced and naturally occurring.

RCRA (Resource Conservation and Recovery Act) Pronounced “rick-rah,” this act of Congress gave **EPA** the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of nonhazardous wastes. The 1986 amendments to RCRA enabled **EPA** to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (*see CERCLA*). In 1984, amendments to RCRA called the Hazardous and Solid Waste Amendments (HSWA, pronounced “hiss-wa”) required phasing out the land disposal of hazardous waste. Some other mandates of this strict law include increased enforcement authority for **EPA**, more stringent hazardous waste management standards, and a comprehensive underground storage tank (UST) program.

recharge – The process by which water is added to a zone of saturation (aquifer) from surface infiltration, typically when rainwater soaks through the earth to reach an aquifer.

recharge basin – A basin (natural or artificial) that collects water. The water will infiltrate to the aquifer.

release – Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment. The National Contingency Plan also defines the term to include a threat of release.

rem – Stands for “**roentgen** equivalent man,” a unit by which human radiation dose is assessed (*see also Sv*). The rem is a risk-based value used to estimate the potential health effects to an exposed individual or population. 100 rem = 1 sievert.

remedial (or remediation) alternatives – Options considered under **CERCLA** for decontaminating a site such as an operable unit (**OU**) or area of concern (**AOC**). Remedial actions are long-term activities that prevent the possible release, or stop or substantially reduce the actual release, of substances that are hazardous but not immediately life-threatening. *See also* feasibility study (**FS**) and Record of Decision (**ROD**).

residual fuel – Crude oil, Nos. 1 and 2 fuel oil that have a nitrogen content greater than 0.05 weight percent, and all fuel oil Nos. 4, 5, and 6, as defined by the American Society of Testing and Materials in ASTM D396-78, *Standard Specifications for Fuel Oils*, (c. 2001).

riparian – An organism living on the bank of a river, lake, or tidewater.

ROD (Record of Decision) – A document that records a regulatory agency’s decision for the selected remedial ac-

tion. The ROD also includes a responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and implementation can begin.

roentgen – See R.

RPD (relative percent difference) – A measure of precision, expressed by the formula: $RPD = [(A-B)/(A+B)] \times 200$, where A equals the concentration of the first analysis and B equals the concentration of the second analysis.

runoff – The movement of water over land. Runoff can carry pollutants from the land into surface waters or uncontaminated land.

S

sampling – The extraction of a prescribed portion of an effluent stream or environmental media for purposes of inspection or analysis.

SARA (Superfund Amendments and Reauthorization Act) – This Act of Congress in 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Title III of SARA also authorized EPCRA.

SBMS (Standards-Based Management System) – A document management tool used to develop and integrate systems, and to demonstrate BNL's conformance to requirements to perform work safely and efficiently.

scintillation – Flashes of light produced in a phosphor by a radioactive material.

Scope 1 emissions – Direct greenhouse gas emissions from sources that are owned or controlled by a Federal agency.

Scope 2 emissions – Indirect greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency.

Scope 3 emissions – Greenhouse gas emissions from sources not owned or directly controlled by a Federal agency, but related to agency activities such as vendor supply chains, delivery services, and employee travel and commuting.

SDWA (Safe Drinking Water Act) – The Safe Drinking Water Act was established to protect the quality of drinking water in the United States. It focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources. The SDWA authorized EPA to establish safe standards of purity and required all owners or operators of public water systems to comply with health-related standards. State governments assume regulatory power from EPA.

sediment – The layer of soil and minerals at the bottom of surface waters, such as streams, lakes, and rivers.

sensitivity – The minimum amount of an analyte that can be repeatedly detected by an instrument.

sievert – See Sv.

skyshine – Radiation emitted upward from an open-topped, shielded enclosure and reflected downward, resulting in the possibility that flora and fauna (including humans) outside the shielded enclosure can be exposed to radiation.

sludge – Semisolid residue from industrial or water treatment processes.

sole source aquifer – An area defined by EPA as being the primary source of drinking water for a particular region. Includes the surface area above the sole source aquifer and its recharge area.

SPDES (State Pollutant Discharge Elimination System) This permit program is delegated to the states, but the effluent limitations and other requirements are set by the federal government. 6 NYCRR Section 750-1.11(a) concerns the provisions of SPDES permits and lists the citations for the various effluent limitations from the Federal Register and the CFR.

stable – Nonradioactive.

stakeholder – People or organizations with vested interests in BNL and its environment and operations. Stakeholders include federal, state, and local regulators; the public; DOE; and BNL staff.

stripping – A process used to remove volatile contaminants from a substance (*see also* air stripping).

sulfur hexafluoride (SF₆) – One of six primary GHGs, consisting of a single sulfur atom and six fluoride atoms, a GWP of 23,900, and primarily used in electrical transmission and distribution systems.

sump – A pit or tank that catches liquid runoff for drainage or disposal.

Sv (sievert) – A unit for assessing the risk of human radiation dose, used internationally and with increasing frequency in the United States. One sievert is equal to 100 rem.

SVE (soil vapor extraction) – An *in situ* (in-place) method of extracting VOCs from soil by applying a vacuum to the soil and collecting the air, which can be further treated to remove the VOCs, or discharged to the atmosphere.

SVOC – A general term for volatile organic compounds that vaporize relatively slowly at standard temperature and pressure. See also VOC.

synoptic – Relating to or displaying conditions as they occur over a broad area.

T

t_{1/2} (half-life) – The time required for one-half of the atoms of any given amount of a radioactive substance to disintegrate; the time required for the activity of a radioactive sample to be reduced by one half.

TCE (trichloroethylene, also known as trichloroethene) A stable, colorless liquid with a low boiling point. TCE has many industrial applications, including use as a solvent and as a metal degreasing agent. TCE may be toxic when inhaled or ingested, or through skin contact, and can damage vital organs, especially the liver. *See also* VOC.

Tier III reports – Reports, required by **SARA**, that are prepared to document annual emissions of toxic materials to the environment. These are also known as TRI Section 313 reports.

TLD (thermoluminescent dosimeter) – A device used to measure radiation dose to occupational workers or radiation levels in the environment.

tritium – The heaviest and only radioactive nuclide of hydrogen, with a **half-life** of 12.3 years and a very-low-energy radioactive decay (tritium is a **beta** emitter).

TSCA (Toxic Substances Control Act) – Enacted by Congress in 1976, TSCA empowers **EPA** to track the 75,000 industrial chemicals produced or imported into the United States. EPA repeatedly screens these chemicals and can require reporting or testing of any that may pose an environmental or human health hazard. EPA can ban the manufacture or import of chemicals that pose an unreasonable risk.

TVOC (total volatile organic compounds) – A sum of all individual **VOC** concentrations detected in a given sample.

U

UIC (underground injection control) – A hole with vertical dimensions greater than its largest horizontal dimensions; used for disposal of wastewater.

UST (underground storage tank) – A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10 percent or more of the volume of the tank system is below the surface of the ground.

upgradient/upslope – A location of higher **groundwater** elevation; analogous to “upstream.”

V

vadose – Relating to water in the ground that is above the permanent groundwater level.

vernal pool – A small, isolated, and contained basin that holds water on a temporary basis, most commonly during winter and spring. It has no aboveground outlet for water and is extremely important to the life cycle of many amphibians (such as the tiger salamander), as it is too shallow to support fish, a major predator of amphibian larvae.

VOC (volatile organic compound) – A general term for organic compounds capable of a high degree of vaporization at standard temperature and pressure. Because VOCs readily evaporate into the air, the potential for human exposure is greatly increased. Due to widespread industrial use, VOCs are commonly found in soil and groundwater.

VUV – Stands for “very ultraviolet” and refers to a beam-line at the NSLS with wavelengths at the far ultraviolet end of the spectrum.

W

waste minimization – Action that avoids or reduces the generation of waste, consistent with the general goal of minimizing current and future threats to human health, safety, and the environment. Waste minimization activities include recycling, improving energy usage, reducing waste at the source, and reducing the toxicity of hazardous waste. This action is associated with pollution prevention, but is more likely to occur after waste has been generated.

water table – The water-level surface below the ground where the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer will fill with water.

watershed – The region draining into a river, a river system, or a body of water.

weighting factor – A factor which, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body. *See also* **EDE**.

wet weight – The wet weight concentration of a substance is before a sample is dried for analysis (in other words, in its “natural” state), and is the form most likely to be consumed. Wet weight concentrations are typically lower than dry weight values.

wind rose – A diagram that shows the frequency of wind from different directions at a specific location.

X

x-rays – A form of electromagnetic **radiation** with short wavelength, generated when high-energy electrons strike matter or when lower-energy **beta** radiation is absorbed in matter. **Gamma** radiation and x-rays are identical, except for the source.

Z

zeolite – A naturally occurring group of more than 100 minerals, formed of silicates and aluminum, with unique and diverse crystal properties. Zeolites can perform ion exchange, filtering, odor removal, and chemical sieve and gas absorption tasks. Synthetic zeolites are now used for most applications.

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Understanding Radiation

This section introduces the general reader to some basic concepts of radioactivity and an understanding of the radiation emitted as radioactive materials decay to a stable state. To better comprehend the radiological information in the Site Environmental Report (SER), it is important to remember that not all radiations are the same and that different kinds of radiation affect living beings differently.

This appendix includes discussions on the common sources of radioactivity in the environment, types of radiation, the analyses used to quantify radioactive material, and how radiation sources contribute to radiation dose. Some general statistical concepts are also presented, along with a discussion of radionuclides that are of environmental interest at BNL. The discussion begins with some definitions and background information on scientific notation and numerical prefixes used when measuring dose and radioactivity. The definitions of commonly used radiological terms are found in the Technical Topics section of the glossary, Appendix A, and are indicated in boldface type here only when the definition in the glossary provides additional details.

RADIOACTIVITY AND RADIATION

All substances are composed of atoms that are made of subatomic particles: protons, neutrons, and electrons. The protons and neutrons are tightly bound together in the positively charged nucleus (plural: nuclei) at the center of the atom. The nucleus is surrounded by a cloud of negatively charged electrons. Most nuclei are stable because the forces holding the protons and neutrons together are strong enough to overcome the electrical energy that tries to push them apart. When the number of neutrons in the nucleus exceeds a threshold, then the nucleus becomes unstable and will spontaneously “decay,” or emit excess energy (“nuclear” energy) in the form of charged particles or electromagnetic waves. Radiation is the excess energy released by unstable atoms. Radioactivity and radioactive refer to the unstable nuclear property of a substance (e.g., radioactive uranium). When a charged particle or electromagnetic wave is detected by radiation-sensing equipment, this is referred to as a radiation event.

Radiation that has enough energy to remove electrons from atoms within material (a process called ionization) is classified as ionizing radiation. Radiation that does not have enough energy to remove electrons is called nonionizing radiation. Examples of nonionizing radiation include most visible light, infrared light, microwaves, and radio waves. All radiation, whether

ionizing or not, may pose health risks. In the SER, radiation refers to ionizing radiation.

Radioactive elements (or radionuclides) are referred to by name followed by a number, such as cesium-137. The number indicates the mass of that element and the total number of neutrons and protons contained in the nucleus of the atom. Another way to specify cesium-137 is Cs-137, where Cs is the chemical symbol for cesium in the Periodic Table of the Elements. This type of abbreviation is used throughout the SER.

SCIENTIFIC NOTATION

Most numbers used for measurement and quantification in the SER are either very large or very small, and many zeroes would be required to express their value. To avoid this, scientific notation is used, with numbers represented in multiples of 10. For example, the number two million five hundred thousand (two and a half million, or 2,500,000) is written in scientific notation as 2.5×10^6 , which represents “2.5 multiplied by 10 raised to the power of 6.” Since even “ 2.5×10^6 ” can be cumbersome, the capital letter E is substituted for the phrase “10 raised to the power of ...” Using this format, 2,500,000 is represented as 2.5E+06. The “+06” refers to the number of places the decimal point was moved to the left to create the shorter version. Scientific notation is also used to represent numbers smaller than zero, in which case a

Figure B-1. Typical Annual Radiation Doses from Natural and Man-Made Sources (mrem). Source: NCRP Report No. 93 (NCRP 1987)

minus sign follows the E rather than a plus. For example, 0.00025 can be written as 2.5×10^{-4} or 2.5E-04. Here, “-04” indicates the number of places the decimal point was moved to the right.

NUMERICAL PREFIXES

Another method of representing very large or small numbers without using many zeroes is to use prefixes to represent multiples of ten. For example, the prefix *milli* (abbreviated m) means that the value being represented is one-thousandth of a whole unit; 3 mg (milligrams) is 3 thousandths of a gram or E-03. See Appendix C for additional common prefixes, including *pico* (p), which means trillionth or E-12, *giga* (G), which means billion or E+09, and *tera* (T), which means trillion, E+12.

SOURCES OF IONIZING RADIATION

Radiation is energy that has both natural and manmade sources. Some radiation is essential to life, such as heat and light from the sun. Exposure to high-energy (ionizing) radiation has to be managed, as it can pose serious health risks at large doses. Living things are exposed to radiation from natural background sources: the atmosphere, soil, water, food, and even our own bodies. Humans are exposed to ionizing radiation from a variety of common sources, the most significant of which follow.

Background Radiation – Radiation that occurs naturally in the environment is also called background activity. Background radiation consists

of cosmic radiation from outer space, radiation from radioactive elements in soil and rocks, and radiation from radon and its decay products in air. Some people use the term background when referring to all non-occupational sources commonly present. Other people use natural to refer only to cosmic and terrestrial sources, and background to refer to common man-made sources such as medical procedures, consumer products, and radioactivity present in the atmosphere from former nuclear testing. In the SER, the term natural background is used to refer to radiation from cosmic and terrestrial radiation.

Cosmic – Cosmic radiation primarily consists of charged particles that originate in space, beyond the earth’s atmosphere. This includes ionizing radiation from the sun, and secondary radiation generated by the entry of charged particles into the earth’s atmosphere at high speeds and energies. Radioactive elements such as hydrogen-3 (tritium), beryllium-7, carbon-14, and sodium-22 are produced in the atmosphere by cosmic radiation. Exposure to cosmic radiation increases with altitude, because at higher elevations the atmosphere and the earth’s magnetic field provide less shielding. Therefore, people who live in the mountains are exposed to more cosmic radiation than people who live at sea level. The average dose from cosmic radiation to a person living in the United States is approximately 26 mrem per year. (For an explanation of dose, see *effective dose equivalent* in Appendix A. The units *rem* and *sieverts* also are explained in Appendix A.)

Terrestrial – Terrestrial radiation is released by radioactive elements that have been present in the soil since the formation of the earth. Common radioactive elements that contribute to terrestrial exposure include isotopes of potassium, thorium, actinium, and uranium. The average dose from terrestrial radiation to a person living in the United States is approximately 28 mrem per year, but may vary considerably depending on the local geology.

Internal – Internal exposure occurs when radionuclides are ingested, inhaled, or absorbed through the skin. Radioactive material may be incorporated into food through the uptake of terrestrial radionuclides by plant roots. People can

ingest radionuclides when they eat contaminated plant matter or meat from animals that have consumed contaminated plants. The average dose from food for a person living in the United States is about 40 mrem per year. A larger exposure, for most people, comes from breathing the decay products of naturally occurring radon gas. The average dose from breathing air with radon byproducts is about 200 mrem per year, but that amount varies depending on geographical location. An Environmental Protection Agency (EPA) map shows that BNL is located in one of the regions with the lowest potential radon risk.

Medical – Every year in the United States, millions of people undergo medical procedures that use ionizing radiation. Such procedures include chest and dental x-rays, mammography, thallium heart stress tests, and tumor irradiation therapies. The average doses from nuclear medicine and x-ray examination procedures are about 14 and 39 mrem per year, respectively.

Anthropogenic – Sources of anthropogenic (man-made) radiation include consumer products such as static eliminators (containing polonium-210), smoke detectors (containing americium-241), cardiac pacemakers (containing plutonium-238), fertilizers (containing isotopes from uranium and thorium decay series), and tobacco products (containing polonium-210 and lead-210). The average dose from consumer products to a person living in the United States is 10 mrem per year (excluding tobacco contributions).

COMMON TYPES OF IONIZING RADIATION

The three most common types of ionizing radiation are described below.

Alpha Radiation – An alpha particle is identical in makeup to the nucleus of a helium atom, consisting of two neutrons and two protons. Alpha particles have a positive charge and have little or no penetrating power in matter. They are easily stopped by materials such as paper and have a range in air of only an inch or so. However, if alpha-emitting material is ingested, alpha particles can pose a health risk inside the body. Naturally occurring radioactive elements such as uranium emit alpha radiation.

Beta Radiation – Beta radiation is composed of particles that are identical to electrons.

Therefore, beta particles have a negative charge. Beta radiation is slightly more penetrating than alpha radiation, but most beta radiation can be stopped by materials such as aluminum foil and plexiglass panels. Beta radiation has a range in air of several feet. Naturally occurring radioactive elements such as potassium-40 emit beta radiation. Some beta particles present a hazard to the skin and eyes.

Gamma Radiation – Gamma radiation is a form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. Gamma rays are emitted from a radioactive nucleus along with alpha or beta particles. Gamma radiation is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete. Gamma radiation is identical to x-rays except that x-rays are more energetic. Only a fraction of the total gamma rays a person is exposed to will interact with the human body.

TYPES OF RADIOLOGICAL ANALYSES

The amount of radioactive material in a sample of air, water, soil, or other material can be assessed using several analyses, the most common of which are described below.

Gross alpha – Alpha particles are emitted from radioactive material in a range of different energies. An analysis that measures all alpha particles simultaneously, without regard to their particular energy, is known as a gross alpha activity measurement. This type of measurement is valuable as a screening tool to indicate the total amount but not the type of alpha-emitting radionuclides that may be present in a sample.

Gross beta – This is the same concept as that for gross alpha analysis, except that it applies to the measurement of gross beta particle activity.

Tritium – Tritium radiation consists of low-energy beta particles. It is detected and quantified by liquid scintillation counting. More information on tritium is presented in the section Radionuclides of Environmental Interest, later in this appendix.

Strontium-90 – Due to the properties of the radiation emitted by strontium-90 (Sr-90), a special analysis is required. Samples are chemically processed to separate and collect any

strontium atoms that may be present. The collected atoms are then analyzed separately. More information on Sr-90 is presented in the section Radionuclides of Environmental Interest.

Gamma – This analysis technique identifies specific radionuclides. It measures the particular energy of a radionuclide’s gamma radiation emission. The energy of these emissions is unique for each radionuclide, acting as a “fingerprint” to identify it.

STATISTICS

Two important statistical aspects of measuring radioactivity are uncertainty in results, and negative values.

Uncertainty – Because the emission of radiation from an atom is a random process, a sample counted several times usually yields a slightly different result each time; therefore, a single measurement is not definitive. To account for this variability, the concept of uncertainty is applied to radiological data. In the SER, analysis results are presented in an $x \pm y$ format, where “x” is the analysis result and “ $\pm y$ ” is the 95 percent “confidence interval” of that result. That means there is a 95 percent probability that the true value of x lies between $(x + y)$ and $(x - y)$.

Negative values – There is always a small amount of natural background radiation. The laboratory instruments used to measure radioactivity in samples are sensitive enough to measure the background radiation along with any contaminant radiation in the sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured. Due to the randomness of radioactive emissions and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported, even though doing so may seem illogical, but they are essential when conducting statistical evaluations of data.

Radiation events occur randomly; if a radioactive sample is counted multiple times, a spread,

or distribution, of results will be obtained. This spread, known as a Poisson distribution, is centered about a mean (average) value. Similarly, if background activity (the number of radiation events observed when no sample is present) is counted multiple times, it also will have a Poisson distribution. The goal of a radiological analysis is to determine whether a sample contains activity greater than the background reading detected by the instrument. Because the sample activity and the background activity readings are both Poisson distributed, subtraction of background activity from the measured sample activity may result in values that vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) was established to determine the statistical likelihood that a sample’s activity is greater than the background reading recorded by the instrument.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. Most laboratories set their acceptance of a Type I error at 5 percent when calculating the MDL for a given analysis. That is, for any value that is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values that are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all radiological data are reported, regardless of whether they are positive or negative.

At very low sample activity levels that are close to the instrument’s background reading, it is possible to obtain a sample result that is less than zero. This occurs when the background activity is subtracted from the sample activity to obtain a net value, and a negative value results. Due to this situation, a single radiation event observed during a counting period could have a significant effect on the mean (average) value result. Subsequent analysis may produce a sample result that is positive. When the annual data for the SER are compiled, results may be averaged; therefore, all negative values are retained for reporting as well. This data handling practice is consistent with the guidance provided in the Handbook of

Radioactivity Measurements Procedures (NCRP 1985) and the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE 1991). Average values are calculated using actual analytical results, regardless of whether they are above or below the MDL, or even equal to zero. The uncertainty of the mean, or the 95 percent confidence interval, is determined by multiplying the population standard deviation of the mean by the $t_{(0.05)}$ statistic.

RADIONUCLIDES OF ENVIRONMENTAL INTEREST

Several types of radionuclides are found in the environment at BNL due to historical operations.

Cesium-137 – Cs-137 is a fission-produced radionuclide with a half-life of 30 years (after 30 years, only one half of the original activity level remains). It is found in the worldwide environment as a result of past aboveground nuclear weapons testing and can be observed in near-surface soils at very low concentrations, usually less than 1 pCi/g (0.004 Bq/g). Cs-137 is a beta-emitting radionuclide, but it can be detected by gamma spectroscopy because its decay product, barium-137m, emits gamma radiation.

Cs-137 is found in the environment at BNL mainly as a soil contaminant, from two main sources. The first source is the worldwide deposition from nuclear accidents and fallout from weapons testing programs. The second source is deposition from spills or releases from BNL operations. Nuclear reactor operations produce Cs-137 as a byproduct. In the past, wastewater containing small amounts of Cs-137 generated at the reactor facilities was routinely discharged to the Sewage Treatment Plant (STP), resulting in low-level contamination of the STP and the Peconic River. In 2002/2003, under the Environmental Restoration Program, sand and its debris containing low levels of Cs-137, Sr-90, and heavy metals were removed, assuring that future discharges from the STP are free of these contaminants. Soil contaminated with Cs-137 is associated with the following areas that have been, or are being, addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility,

Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, and the Brookhaven Graphite Research Reactor (BGRR).

Strontium-90 – Sr-90 is a beta-emitting radionuclide with a half-life of 28 years. Sr-90 is found in the environment principally as a result of fallout from aboveground nuclear weapons testing. Sr-90 released by weapons testing in the 1950s and early 1960s is still present in the environment today. Additionally, nations that were not signatories of the Nuclear Test Ban Treaty of 1963 have contributed to the global inventory of fission products (Sr-90 and Cs-137). This radionuclide was also released as a result of the 1986 Chernobyl accident in the former Soviet Union.

Sr-90 is present at BNL in the soil and groundwater. As in the case of Cs-137, some Sr-90 at BNL results from worldwide nuclear testing; the remaining contamination is a by-product of reactor operations. The following areas with Sr-90 contamination have been or are being addressed as part of the Environmental Remediation Program: former Hazardous Waste Management Facility, Waste Concentration Facility, Building 650 Reclamation Facility and Sump Outfall Area, the BGRR, Former and Interim Landfills, Chemical and Glass Holes Area, and the STP.

The information in SER tables is arranged by method of analysis. Because Sr-90 requires a unique method of analysis, it is reported as a separate entry. Methods for detecting Sr-90 using state-of-the-art equipment are quite sensitive (detecting concentrations less than 1 pCi/L), which makes it possible to detect background levels of Sr-90.

Tritium – Among the radioactive materials that are used or produced at BNL, tritium has received the most public attention. Approximately 4 million Ci ($1.5E+5$ TBq) per year are produced in the atmosphere naturally (NCRP 1979). As a result of aboveground weapons testing in the 1950s and early 1960s in the United States, the global atmospheric tritium inventory was increased by a factor of approximately 200. Other human activities such as consumer product manufacturing and nuclear power reactor operations have also released tritium into the

environment. Commercially, tritium is used in products such as self-illuminating wristwatches and exit signs (the signs may each contain as much as 25 Ci [925 GBq] of tritium). Tritium also has many uses in medical and biological research as a labeling agent in chemical compounds, and is frequently used in universities and other research settings such as BNL and other national laboratories.

Of the sources mentioned above, the most significant contributor to tritium in the environment has been aboveground nuclear weapons testing. In the early 1960s, the average tritium concentration in surface streams in the United States reached a value of 4,000 pCi/L (148 Bq/L; NCRP 1979). Approximately the same concentration was measured in precipitation. Today, the level of tritium in surface waters in New York State is less than one-twentieth of that amount, below 200 pCi/L (7.4 Bq/L; NYSDOH 1993). This is less than the detection limit of most analytical laboratories.

Tritium has a half-life of 12.3 years. When an atom of tritium decays, it releases a beta particle, causing transformation of the tritium atom into stable (nonradioactive) helium. The beta radiation that tritium releases has a very low energy, compared to the emissions of most other radioactive elements. In humans, the outer layer of dead skin cells easily stops the beta radiation from tritium; therefore, only when tritium is taken into the body can it cause an exposure. Tritium may be taken into the body by inhalation, ingestion, or absorption of tritiated water through the skin. Because of its low energy radiation and short residence time in the body, the health threat posed by tritium is very small for most exposures.

Environmental tritium is found in two forms: gaseous elemental tritium, and tritiated water or water vapor, in which at least one of the hydrogen atoms in the H₂O water molecule has been replaced by a tritium atom (hence, its shorthand notation, HTO). Most of the tritium released from BNL sources is in the form of HTO, none as elemental tritium. Sources of tritium at BNL include the reactor facilities (all now non-operational), where residual water (either heavy or light) is converted to tritium via neutron

bombardment; the accelerator facilities, where tritium is produced by secondary radiation interactions with soil and water; and facilities like the Brookhaven Linac Isotope Producer, where tritium is formed from secondary radiation interaction with cooling water. Tritium has been found in the environment at BNL as a groundwater contaminant from operations in the following areas: Current Landfill, BLIP, Alternating Gradient Synchrotron, and the High Flux Beam Reactor. Although small quantities of tritium are still being released to the environment through BNL emissions and effluents, the concentrations and total quantity have been drastically reduced, compared with historical operational releases as discussed in Chapters 4 and 5.

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Units of Measure and Half-Life Periods

UNITS OF RADIATION MEASUREMENT AND CONVERSIONS

U.S. System	International System	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

APPROXIMATE METRIC CONVERSIONS

When you know	multiply by	to obtain	When you know	multiply by	to obtain
centimeters (cm)	0.39	inches (in.)	in.	2.54	cm
meters (m)	3.28	feet (ft)	ft	0.305	m
kilometers (km)	0.62	miles (mi)	mi	1.61	km
kilograms (kg)	2.20	pounds (lb)	lb	0.45	kg
liters (L)	0.264	gallons (gal)	gal	3.785	L
cubic meters (m ³)	35.32	cubic feet (ft ³)	ft ³	0.03	m ³
hectares (ha)	2.47	acres	acres	0.40	ha
square kilometers (km ²)	0.39	square miles (mi ²)	mi ²	2.59	km ²
degrees Celcius (°C)	1.8 (°C) + 32	degrees Fahrenheit (°F)	°F	(°F - 32) / 1.8	°C

SCIENTIFIC NOTATION USED FOR MEASUREMENTS

Multiple	Decimal Equivalent	Notation	Prefix	Symbol
1 x 10 ¹²	1,000,000,000,000	E+12	Tera-	T
1 x 10 ⁹	1,000,000,000	E+9	giga-	G
1 x 10 ³	1,000	E+03	kilo-	k
1 x 10 ⁻²	0.01	E-02	centi-	c
1 x 10 ⁻³	0.001	E-03	milli-	m
1 x 10 ⁻⁶	0.000001	E-06	micro-	μ
1 x 10 ⁻⁹	0.000000001	E-09	nano-	n
1 x 10 ⁻¹²	0.000000000001	E-12	pico-	p

CONCENTRATION CONVERSIONS

1 ppm	=	1,000 ppb
1 ppb	=	0.001 ppm = 1 μg/L *
1 ppm	=	1 mg/L = 1000 μg/L *

* For aqueous fractions only.

APPENDIX C: Units of Measure and Half-Life Periods

HALF-LIFE PERIODS	
Am-241	432.7 yrs
C-11	~20 min
Co-60	5.3 yrs
Cs-137	30.2 yrs
N-13	~10 min
N-22	2.6 yrs
O-15	~2 min
PU-238	87.7 yrs
Pu-239	24,100.0 yrs
Pu-240	6,560.0 yrs
Sr-90	29.1 yrs
tritium	12.3 yrs
U-234	247,000.0 yrs
U-235	~700 million yrs (7.0004E8)
U-238	87.7 yrs

Federal, State, and Local Laws and Regulations Pertinent to BNL

DOE DIRECTIVES, REGULATIONS, AND STANDARDS

DOE O 231.1B	Order: Environment, Safety and Health Reporting	06/27/2011
DOE O 414.1D	Order: Quality Assurance	08/16/2001
DOE O 435.1	Order: Change 1: Radioactive Waste Management	07/09/1999
DOE P 450.5	Policy: Line Environment, Safety, and Health Oversight	06/26/1997
DOE O 458.1	Order: Radiation Protection of the Public and the Environment	02/11/2011
DOE O 436.1	Order: Departmental Sustainability	05/02/2011

FEDERAL LAWS AND REGULATIONS

EO 13148	Greening of the Government Through Leadership in Environmental Management
EO 13423	Strengthening Federal Environmental, Energy and Transportation Management
EO 13514	Federal leadership in Environmental, Energy, and Economic Performance
10 CFR 1021	National Environmental Protection Act, Implementing and Procedures
10 CFR 1022	Compliance with Floodplain/Wetlands Environmental Review Requirements
10 CFR 830	Subpart A: Quality Assurance Requirements
10 CFR 834	Radiation Protection of the Public and the Environment
16 USC 470	National Historic Preservation Act
36 CFR 60	National Register of Historic Places
36 CFR 63	Determination of Eligibility for Inclusion in the National Register of Historic Places
36 CFR 79	Curation of Federally Owned and Administered Archaeological Collections
36 CFR 800	Protection of Historic Properties
40 CFR 50-0	National Primary and Secondary Ambient Air Quality Standards
40 CFR 82	Protection of Stratospheric Ozone
40 CFR 109	Criteria for State, Local and Regional Oil Removal Contingency Plans
40 CFR 110	Discharge of Oil
40 CFR 112	Oil Pollution Prevention Act
40 CFR 113	Liability Limits for Small Onshore Storage Facilities
40 CFR 116	Designation of Hazardous Substances
40 CFR 117	Determination of Reportable Quantities for Hazardous Substances

APPENDIX D: FEDERAL, STATE, AND LOCAL LAWS
AND REGULATIONS PERTINENT TO BNL

40 CFR 121	State Certification of Activities Requiring a Federal License or Permit
40 CFR 122	National Pollution Discharge Elimination System (NPDES)
40 CFR 123	State Program Requirements
40 CFR 124	Procedures for Decision-making
40 CFR 125	Criteria and Standards for the National Pollutant Discharge Elimination System
40 CFR 129	Toxic Pollutant Effluent Standards
40 CFR 130	Water Quality Planning and Management
40 CFR 131	Water Quality Standards
40 CFR 132	Water Quality Guidance for the Great Lakes System
40 CFR 133	Secondary Treatment Regulation
40 CFR 135	Prior Notice of Citizen Suits
40 CFR 136	Guidelines Establishing Test Procedures for the Analysis of Pollutants
40 CFR 141	National Primary Drinking Water Regulations
40 CFR 142	National Primary Drinking Water Regulations Implementation
40 CFR 143	National Secondary Drinking Water Regulations
40 CFR 144	Underground Injection Control (UIC) Program
40 CFR 146	Underground Injection Control (UIC) Program: Criteria and Standards
40 CFR 148	Hazardous Waste Injection Restrictions
40 CFR 149	Sole Source Aquifers
40 CFR 167	Submissions of Pesticide Reports
40 CFR 168	Statements of Enforcement Policies and Interpretations
40 CFR 169	Books and Records of Pesticide Production and Distribution
40 CFR 170	Worker Protection Standard
40 CFR 171	Certification of Pesticide Applicators
40 CFR 260	Hazardous Waste Management Systems: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 266	Standards for the Management of Special Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities

APPENDIX D: FEDERAL, STATE, AND LOCAL LAWS
AND REGULATIONS PERTINENT TO BNL

40 CFR 268	Land Disposal Restrictions
40 CFR 270	EPA Administered Permit Program: The Hazardous Waste Permit Program
40 CFR 271	Requirements for Authorization of State Hazardous Waste Mgmt Programs
40 CFR 272	Approved State Hazardous Waste Management Programs
40 CFR 273	Standards for Universal Waste Management
40 CFR 279	Standards for the Management of Used Oil
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 355	Emergency Planning and Notification
40 CFR 370	Hazardous Chemical Report: Community Right-to-Know
40 CFR 372	Toxic Chemical Release Report: Community Right-to-Know
40 CFR 700	Toxic Substances Control Act [TSCA]
40 CFR 702	Toxic Substances Control Act: General Practices and Procedures
40 CFR 704	Toxic Substances Control Act: Reporting and Recordkeeping Requirements
40 CFR 707	Chemical Imports and Exports
40 CFR 710	Inventory Reporting Regulations
40 CFR 712	Chemical Information Rules
40 CFR 716	Health and Safety Data Reporting
40 CFR 717	Records and Reports of Allegations that Chemical Substances Cause Significant Adverse Reactions to Health or the Environment
40 CFR 720	Premanufacture Notification
40 CFR 721	Significant New Users of Chemical Substances
40 CFR 723	Premanufacture Notification Exemptions
40 CFR 725	Reporting Requirements and Review Processes for Microorganisms
40 CFR 745	Lead-Based Paint Poisoning Prevention in Certain Residential Structures
40 CFR 747	Metalworking Fluids
40 CFR 749	Water Treatment Chemicals
40 CFR 750	Procedures for Rulemaking Under Section 6 of TSCA
40 CFR 761	PCBs Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
40 CFR 763	Asbestos
40 CFR 1500	Council on Environmental Quality: Purpose, Policy, and Mandate

APPENDIX D: FEDERAL, STATE, AND LOCAL LAWS AND REGULATIONS PERTINENT TO BNL

40 CFR 1501	NEPA and Agency Planning
40 CFR 1502	Environmental Impact Statement
40 CFR 1503	Commenting
40 CFR 1504	Predecision Referrals to the Council of Proposed Federal Actions
40 CFR 1505	NEPA and Agency Decision-making
40 CFR 1506	Other Requirements of NEPA
40 CFR 1507	Agency Compliance
40 CFR 1508	Terminology and Index
50 CFR 17	Endangered and Threatened Wildlife and Plants

NEW YORK STATE LAWS, REGULATIONS, AND STANDARDS

6 NYCRR 182	Endangered and Threatened Species of Fish and Wildlife, Species of Special Concern
6 NYCRR 200	Environmental Conservation Law
6 NYCRR 201	Subpart 201-1: General Provisions
6 NYCRR 202	Subpart 202: Emissions Verification
6 NYCRR 203	Indirect Sources of Air Contamination
6 NYCRR 204	NO _x Budget Training Program
6 NYCRR 205	Architectural and Maintenance (AIM) Coatings
6 NYCRR 207	Control Measures for an Air Pollution Episode
6 NYCRR 208	Landfill Gas Collection and Control System for Certain Municipal Solid Waste Landfills
6 NYCRR 211	General Prohibitions
6 NYCRR 212	General Process Emission Sources
6 NYCRR 215	Open Fires
6 NYCRR 217	Environmental Conservation Rules and Regulations [Exhaust and Emission Standards]
6 NYCRR 218	Subpart 218-1 [More on Vehicle Exhaust]
6 NYCRR 221	Asbestos-Containing Surface Coating Material
6 NYCRR 225	Subpart 225-1: Fuel Composition and Use – Sulfur Limitations
6 NYCRR 227	Solvent Metal Cleaning Processes
6 NYCRR 228	Surface Coating Processes
6 NYCRR 229	Petroleum and Volatile Organic Liquid Storage and Transfer
6 NYCRR 230	Gasoline Dispensing Sites and Transport Vehicles
6 NYCRR 231	New Source Review in Nonattainment Areas and Ozone Transport Regions
6 NYCRR 234	Graphic Arts

APPENDIX D: FEDERAL, STATE, AND LOCAL LAWS
AND REGULATIONS PERTINENT TO BNL

6 NYCRR 237	Acid Deposition Reduction NO _x Budget Training Program
6 NYCRR 238	Acid Deposition Reduction SO ₂ Budget Training Program
6 NYCRR 239	Portable Fuel Container Spillage Control
6 NYCRR 240	Conformity to State or Federal Implementation Plans
6 NYCRR 250	Miscellaneous Orders
6 NYCRR 256	Air Quality Classification System
6 NYCRR 257	Air Quality Standards
6 NYCRR 307	[Air Quality in] Suffolk County
6 NYCRR 320	Pesticides - General
6 NYCRR 325	Application of Pesticides
6 NYCRR 326	Registration and Certification of Pesticides
6 NYCRR 327	Use of Chemicals for the Control or Elimination of Aquatic Vegetation
6 NYCRR 328	Use of Chemicals for the Extermination of Undesirable Fish
6 NYCRR 329	Use of Chemicals for the Control or Elimination of Aquatic Insects
6 NYCRR 360-1	General Provisions: Solid Waste Management Facilities
6 NYCRR 361	Siting of Industrial Hazardous Waste Facilities
6 NYCRR 364	Waste Transporter Permits
6 NYCRR 370	Hazardous Waste Management Regulations
6 NYCRR 371	Identification and Listing of Hazardous Waste
6 NYCRR 372	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities
6 NYCRR 373	Hazardous Waste Management Facilities
6 NYCRR 374	Standards for the Management of Specific Hazardous Wastes
6 NYCRR 376	Land Disposal Restrictions
6 NYCRR 595	Release of Hazardous Substances
6 NYCRR 596	Hazardous Substance Bulk Storage Regulations
6 NYCRR 597	List of Hazardous Substances
6 NYCRR 611	Environmental Priorities and Procedures in Petroleum Cleanup and Removal
6 NYCRR 612	Registration of Petroleum Storage Facilities
6 NYCRR 613	Handling and Storage of Petroleum
6 NYCRR 663	Freshwater Wetlands Permit Requirements
6 NYCRR 666	Regulation for Administration and Management of the Wild, Scenic, and Recreational Rivers System in New York State Excepting Private Land in the Adirondack Park

APPENDIX D: FEDERAL, STATE, AND LOCAL LAWS AND REGULATIONS PERTINENT TO BNL

6 NYCRR 700	Part 700 Water Quality Regulations
6 NYCRR 701	Classification – Surface Waters and Groundwaters
6 NYCRR 702	Derivation and Use of Standards and Guidance Values
6 NYCRR 703	Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations
6 NYCRR 750	Obtaining a SPDES Permit
10 NYCRR 5	State Sanitary Code – Part 5

SUFFOLK COUNTY RULES, REGULATIONS, AND STANDARDS

SCSC Art. 12	Toxic and Hazardous Material Storage, Handling and Control
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2014 Site Environmental Report
Reader Response Form

The 2014 Site Environmental Report (SER) was written to inform regulators, the public, and BNL employees of the Laboratory's environmental performance for the calendar year in review. The report summarizes the Laboratory's on-site environmental data; environmental management performance; compliance with applicable regulations; and environmental, restoration, and surveillance monitoring programs.

BNL welcomes your comments, suggestions for improvements, or any questions you may have. Please fill in the information below, and mail your response form to:

Brookhaven National Laboratory
Environmental Protection Division
Attention: SER Project Coordinator
Building 860
P.O. Box 5000
Upton, NY 11973-5000

Name _____

Address _____

Phone _____

Email _____

Comments, Suggestions, or Questions

☐ I would like to be added to your Environmental Issues mailing list.

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